Development of a Monitoring and Evaluation Framework for the sustainability assessment of Road Freight Transport Systems in South Africa

by

Chumasande Lalendle

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Supervisor: Prof Leila Goedhals-Gerber

Co-supervisor: Dr Joubert Van Eeden

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DECLARATION

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ABSTRACT

Partial national lockdowns implemented globally, including in South Africa, due to the COVID-19 pandemic, significantly impacted the movement of goods, services and people with a dire negative effect on global economies. This has reignited the need for sustainable, resilient, and secure transportation services to meet the basic human needs into the future, post the pandemic. The importance of the freight industry cannot be disputed given the fact that the transportation of essential supply products and services were allowed to continue amid closure of borders and many industries.

Global freight volumes continue to rise and the advancement of megatrends such as globalisation, population growth digitalization, demographic changes and rapid industrialisation are among the primary causes of this phenomenon. However, increased industrial activities and the need for transportation services, negatively impact the functioning of major transport and logistics systems. Moreover, over-reliance on road freight transportation systems (RFTS) over alternative modes of transport puts a strain on the RFTS. Hence, the need to develop a monitoring and evaluation (M&E) sustainability assessment framework to estimate and understand the impact of RFTS on the environment, economy and social aspects of people and their livelihoods.

The study utilised a mixed-method approach guided by a three-stage process. Firstly, a systematic literature review was conducted to understand realities based on the objectives of the study. Secondly, the development of an inventory bank was completed to solicit Key Performance Indicators (KPIs) to be used in the M&E framework, and lastly, findings from the first and second steps were utilised to develop the final M&E sustainability assessment framework.

Results revealed that there are limited resources with frameworks that target all three dimensions of the triple bottom line in the assessment of RFTS. Furthermore, among the existing frameworks, fewer are developed to assess the sustainability of RFTS in the South African context. Given these findings, an M&E framework that focuses on the holistic sustainability of RFTS in South Africa is recommended.

The study makes an original contribution in terms of developing an M&E framework that addresses sustainability challenges in South African RFTS. This affords organisations a tool for tracking inputs towards system sustainability, annual sustainability status, system changes, progress, and decline of sustainability in the RFTS.

Keywords: Frameworks; freight transport; monitoring and evaluation; road transport; sustainability.

OPSOMMING

Gedeeltelike nasionale uitsluitings wat wêreldwyd (insluitend Suid Afrika) geïmplementeer is as gevolg van die COVID-19-pandemie het die beweging van goedere, dienste en mense aansienlik beïnvloed met ernstige negatiewe uitwerkings op die wêreldekonomie. Dit het die behoefte aan volhoubare, veerkragtige en veilige vervoerdienste om die basiese menslike behoeftes in die toekoms (en na die pandemie) te bevredig, weer aangewakker. Die belangrikheid van die vragbedryf kan nie betwyfel word nie aangesien die vervoer van noodsaaklike produkte en dienste toegelaat word te midde van die sluiting van grense en baie industrieë.

Globale vragvolumes styg steeds. Gevolglik is die bevordering van megatendense soos globalisering, digitalisering van bevolkingsgroei en demografiese veranderinge die hoofoorsake van hierdie verskynsel. Groeipatrone het egter 'n negatiewe uitwerking op die belangrikste vervoer- en logistieke stelsels as gevolg van verhoogde nywerheidsaktiwiteite. Verder plaas oormatige afhanklikheid van padvervoerstelsels (RFTS) oor alternatiewe vervoermiddels druk op die RFTS. Daarom is dit nodig om 'n moniterings- en evaluerings (M&E) volhoubaarheidsevaluerings raamwerk te ontwikkel om die impak van RFTS op die omgewing, ekonomie en sosiale aspekte van mense en hul lewensbestaan te skat en te verstaan.

Die studie het 'n gemengde-metode benadering gebruik wat gelei is deur 'n drie fase proses. Eerstens is 'n sistematiese literatuuroorsig gedoen om realiteite te verstaan gebaseer op die doelstellings van die studie. Tweedens is die ontwikkeling van 'n voorraadbank voltooi om sleutelprestasie-aanwysers (KPI's) aan te wend om in die M & E-raamwerk gebruik te word, en laastens is bevindinge uit die eerste en tweede stap gebruik om die finale M & E-raamwerk vir volhoubaarheidsevaluering te ontwikkel.

Resultate het getoon dat daar beperkte hulpbronne is met raamwerke wat al drie dimensies van die driedubbele reël in die beoordeling van RFTS teiken. Onder die bestaande raamwerke is daar ook ook minder ontwikkel wat die volhoubaarheid van RFTS in die Suid-Afrikaanse konteks assesseer. Gegewe hierdie bevindings word 'n M & E-raamwerk aanbeveel wat fokus op die holistiese volhoubaarheid van RFTS in Suid-Afrika.

Die studie lewer oorspronklik 'n bydrae tot die ontwikkeling van 'n M & E-raamwerk wat aandag gee aan volhoubaarheidsuitdagings binne RFTS in Suid-Afrika. Deur organisasies 'n hulpmiddel te gee om hul insette op te spoor ten opsigte van stelselvolhoubaarheid en hul jaarlikse volhoubaarheidstatus, stelselveranderings, vordering en agteruitgang van volhoubaarheid in hul RFTS. Die studie het implikasies vir navorsing, beleid en praktyk.

Sleutelwoorde: Monitering en evaluering; padvervoer; raamwerke; volhoubaarheid; vragvervoer.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

ACCA:	Association of Chartered Certified Accountants
AHP:	Analytical Hierarchy Process
CAIB:	Canadian Accredited Insurance Broker
CBA:	Cost-Benefit Analysis
CEA:	Cost-Effectiveness Analysis
CEO:	Chief Executive Officer
CFO:	Chief Financial Officer
CIO:	Chief Information Officer
CPA:	Certified Public Account
CSR:	Corporate Social Responsibility
DOT:	Department of Transport
FRA:	Feasibility Risk Assessment
GHG:	Greenhouse Gases
HGV:	Heavy Goods Vehicles
ICT:	Information and Communication Technology
IRTAD:	International Traffic Safety Data and Analysis Group
KPI:	Key Performance Indicators
LPI:	Logistics Performance Index
M&E:	Monitoring and Evaluation

MAMCA:	Multi Actor Multi-Criteria Analysis
MCDA:	Multi-Criteria Decision Analysis
RFTS:	Road Freight Transportation System(s)
RQ:	Research Question
SA:	South Africa
SCBA:	Social Cost-Benefit Analysis
SHEQ:	Safety, Health, Environment and Quality
SLR:	Systematic Literature Review
SQAS:	Safety and Quality Assessment for Sustainability
TBL:	Triple Bottom Line
TLR:	Traditional Literature Review
UNFCCC:	United Nations Framework Convention on Climate Change
UNCTAD:	United Nations Conference on Trade and Development
WEF:	World Economic Forum

CHAPTER 1: INTRODUCTION

1.1 Introduction

Sustainable transport is a fundamental development objective that has dominated global development strategies and debates for many years. Global forums such as the United Nations (UN) Conference on Sustainable Development (RIO+20), the 1992 Earth Summit, and more recently, the UN Global Sustainable Transport Conference 2016 attest to this fact. Its recognised importance led to the appointment of a UN Secretary-General High-level Advisory Group on Sustainable Transport in 2014, to develop actionable recommendations on a global, national, and local sphere that address sustainability of transportation systems.

Transport promotes economic and social progress at local, regional and global levels. The use of road transport to ferry freight creates time and place utility for consumers. Modern society relies on efficient and effective road freight transport to receive and distribute goods and services. McKinnon (2006) and Sveriges Akeriforetag (2009) concluded that chaos would occur within a week if, for instance, basic utilities such as the supply of food, delivery of medication to hospitals, and the handling of rubbish were halted for a week. Road transportation, thus, can be seen to be intertwined with the well-being of society both socially and economically. Freight transport plays a critical role in society, and there is an opportunity for the freight transport sector to create economically viable, socially equitable, resource conserved and environmentally protected systems. This was reflected in the United Nations Conference on Trade and Development in 2015 with respect to sustainable freight transport.

Social order changes driven by megatrends like globalisation, population growth, and digitalization, exerts more pressure on the current and future transportation systems (Engström, 2016). The World Economic Forum (2014) describes the forecasted increased pressure as a potential time bomb. Freight transport is part of achieving sustainable development. Hence, it can be better understood by defining sustainability in the context of the transport sector and systems based on sustainability pillars (social, economic, and environmental).

1.2 Background and motivation

The world economic boost currently, can be partially attributed to the transport sector's innovations and development (Agbo, Li, Atombo, Lodewijks, & Zheng, 2017; Mihyeon Jeon, Christy, Adjo, & Vanegas, 2006). Transportation has been an influential part in determining where industries position themselves and humans settle (Agbo *et al*. 2017). A significant

percentage of the world's population live or work in urban locations. With the increasing rural-urban migration, freight and passenger volumes globally in the cities have increased (Beytell, 2012) further exerting excessive pressure on transport systems to meet the growing travel demand.

The development of global supply chains has given rise to bigger and more interconnected transport systems. Transportation is the link in supply chains consisting of suppliers, manufacturers, distributors, retailers, and consumers (Agbo *et al*. 2017). As the demand for products grows, it is important to ensure that consumers and organizations not only consider the marginal private cost, but also the marginal external cost associated with transport systems.

Stretching supply chains across long distances is associated with cost implications. The traditional focus when planning transportation activities is on reducing internal costs and maximizing profits (Gobetto, 2014; Hwang & Ouyang, 2015). This approach is seen particularly in the freight transport sector (Agbo & Zhang, 2017). Freight transport must adapt and develop sustainably in line with the global call across all industries.

Many industries have made efforts to address issues of sustainability in their fields. Particularly in the line of supply chain management and transportation; initiatives towards green design, green purchasing and manufacturing, route and load planning for empty legs and reverse logistics to name a few have been taken (Evangelista, Sweeny, Ferruzzi, & Carrasco, 2010; Grant, Trautrims & Wong, 2017; Banaei-Kashani & Fitzgerald, 2019). However, the negative impacts of freight transportation as a result of all logistics and industrial activity are still starkly present, regardless of the technological and operational efforts (Norojono and Young, 2003; Baindur, and& Viegas, 2011; Gudmundsson, Marsden & Josias, 2016).

Socially, the evident impacts of road freight transport are congestion, crashes and long working hours for drivers who must deliver freight across long distances. Environmentally, the effects include air pollution contributing to climate change (Khorheh, Moisiadis & Davarzani, 2015). Economically, congested roads cost society money and with the increased traffic on the roads there arises the need to service and maintain road infrastructure more frequently (Piecyk & McKinnon, 2007; Engström, 2016). Therefore, a functional society needs transport systems that consider sustainability to provide competitive, integrated and attractive traffic solutions to ensure mobility both for the current and future societies (Beytell, 2012).

1.3 Problem Statement

Overreliance on road freight transport systems (RFTS) from coastlines to remote areas inland has led to the road transportation sector becoming less sustainable (Guo, Peeta, & Mannering, 2016). Transport systems must consider the social, environmental and economic impact of their activities. There are M&E frameworks that investigate the sustainability of transport systems. However, there are gaps in literature around the M&E frameworks that assess sustainability holistically in RFTS. There are gaps in literature linked to M&E frameworks developed for RFTS in South Africa. This study develops an M&E framework that assesses the impact of proposed changes to RFTS according to all three pillars of sustainability, specifically within the South African context.

1.4 Research questions

The following research questions were answered by this study:

1. How is sustainability defined in the road transport sector?
2. What M&E frameworks are available to measure the sustainability of road freight transport systems both globally and in South Africa?
3. Do the available frameworks measure sustainability holistically?
4. How can an M&E framework be developed to measure a road freight transport system's sustainability in South Africa?
5. What international best practices are used in the road freight transport sector?

1.5 Aim and objectives of the study

The aim of the study was to develop an M&E framework for the holistic sustainability of RFTS, to assist organisations to assess and have a tool to track their current sustainability status, system inputs, progress and decline of sustainability in their RFTS. In addition, for the study to contribute towards shared knowledge and ultimately sustainability development of RFTS in South Africa.

1.5.1 Research objectives

The research objectives answered in this thesis are outlined in Table 1.1

Table 1.1: Research objectives and related research questions

Research Question	Research Objective	Addressed in Chapter
1	To determine how sustainability is defined in the transport sector.	2 (Literature Review)
2	To investigate what M&E frameworks there are to measure the sustainability of road freight transport systems globally and in South Africa.	3 (Systematic literature review)
3	To determine if the available frameworks cover sustainability holistically.	3 (Systematic literature review)
4	To develop an M&E framework that will assess the sustainability of road freight transport systems holistically.	4 (Development of an M&E framework)
5	To determine sustainability best practices internationally in the road freight transport sector.	2 (Literature Review)

1.6 Conceptual framework

Figure 1.1 illustrates the conceptual framework used in this study. Literature was reviewed to answer the study's objectives, how to answer the study's research questions as well as develop the sustainability framework. A mixed method was used as shown in Figure 1.1 and explained further in Chapter two. Themes, goals, inputs, measures and the structure of the framework emerged from the traditional literature review (TLR) and the systematic literature review (SLR). Moreover, the framework was reviewed by industry experts and the feedback incorporated into framework.

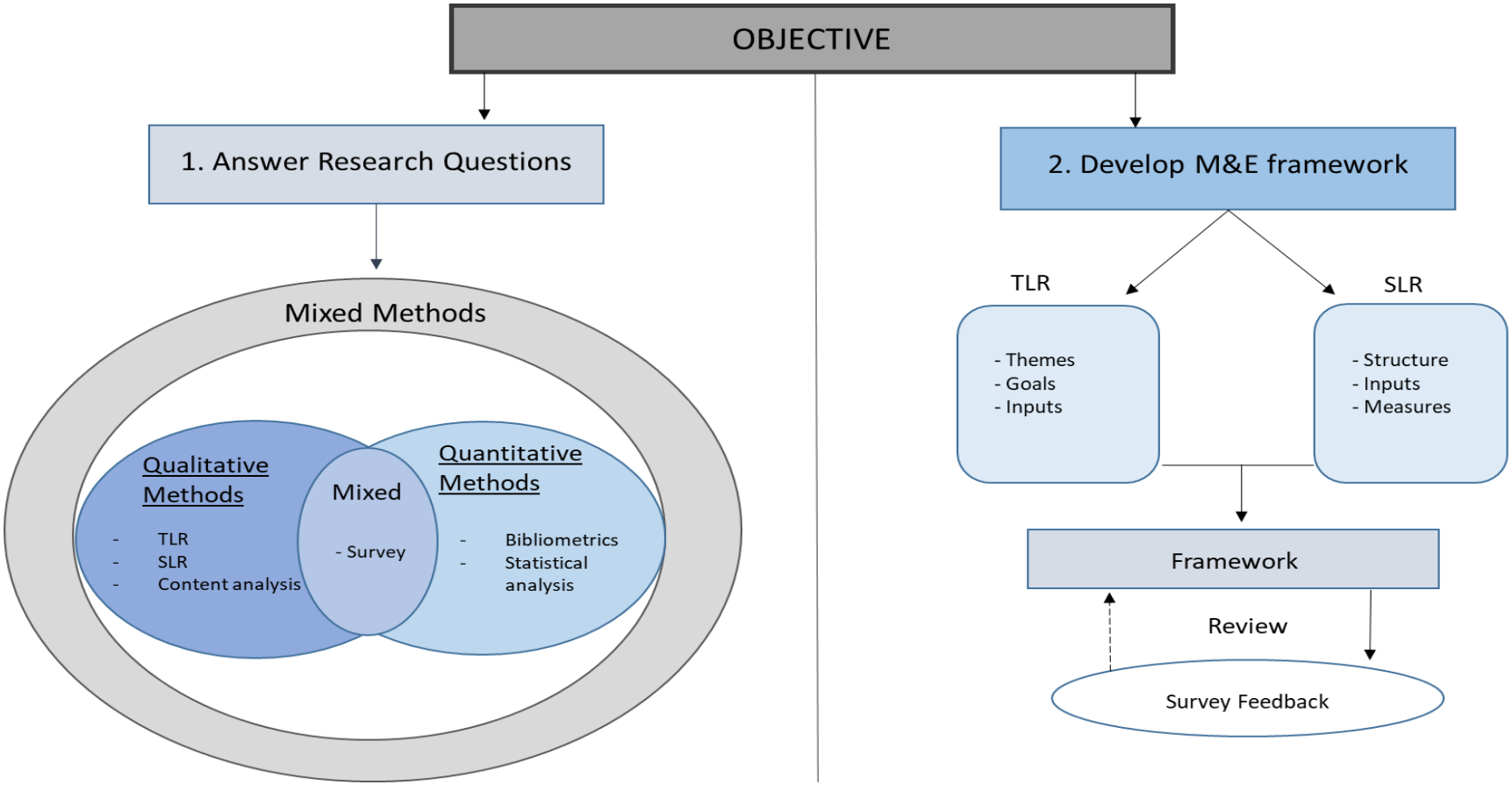


Figure 1.1: Conceptual framework of the study

Source: Created by author, 2020

1.7 Outline of the study

Chapter 1: Introduction to the study

The first chapter introduces the focus of the study and provides the background as well as highlights the problem studied. The chapter outlines study objectives and justifies why the study adds value for both academia and the road freight industry.

Chapter 2: Research design and Methodology

Chapter 2 explains the methods and techniques followed to scientifically respond to the research questions. The study design, methods, constructs and variables, data collection and analysis tools are key topics discussed in this chapter. These show the path that guided the study.

Chapter 3: Traditional literature review:

Chapter three clarifies and lays the foundation of key variables used in the study. These include: freight transport, road freight best practices; sustainability and M&E frameworks. Literature on the main themes of the study is reviewed and explored in greater detail in line with the research objectives and questions.

Chapter 4: Systematic literature review:

Chapter 4 contains the SLR's that were conducted for research question two and three. Specifically, the protocol followed, inclusion and exclusion criterions, search phrases as well as results are shared in this chapter.

Chapter 5: Framework development

Chapter five is centred on the development of the M&E framework. The chapter alludes to the vision of transport sustainability in South Africa; highlights challenges faced within RFTS and defines sustainability in the context of the transport sector. Reviewed literature findings from the SLR was also utilised to develop a sustainability framework, with structural inputs and content. The framework review by industry experts is also included in this chapter.

Chapter 6: Conclusions, Recommendations and Future work

This chapter concludes the study. It summarises the theoretical background and relevant literature findings. This chapter shows whether the study's objectives were met, provides recommendations for sustainability roleplayers and identifies areas of possible future research.

CHAPTER 2: RESEARCH DESIGN AND METHODOLOGY

2.1 Introduction

This chapter outlines the constructs and variables, research design and approach that underpins the study. The specific theory and process followed to facilitate the study's findings are explained. The tools utilised to analyse the data collected are also included. Lastly, this chapter discusses the scope and limitations of the study, the validity and reliability process. Ethical considerations for this study conclude the chapter.

2.2 Constructs and variables

Constructs are broad concepts or subject matter that the study is interested in. Constructs can be simple or complex. Complex constructs contain more than one dimension or facet, however, when combined form the construct (Lavrakas, 2008). Sustainability is the complex construct that this study sought to investigate particularly in the field of road freight transport.

According to Statistic Solutions (2020), breaking down a construct into a measurable form is the development of variables. Williams (1986) defines a variable as "an observable characteristic of an object or event that can be described according to some well-defined classification or measurement scheme". The process of developing variables from constructs is usually seen to occur in the form of an operational definition.

A statement of terms used to describe a phenomenon can be used to define an operational definition. It gives meaning to a variable by detailing the activities needed to measure, categorize, or influence the variable (Slife, Wright, & Yanchar, 2016). In this study, an operational definition for sustainability in the transport sector was formulated. It gives detail of features and elements that must be present for sustainability in the transport sector to be evident. The observable variables of the study are the triple bottom line; social, economic and environmental dimensions of sustainability and road freight transport. These constructs and variables are explored in more detail in the literature reviews.

2.3 Research design

Grounded theory was followed in this study. Grounded theory is a systematic methodology that uses inductive reasoning to create meaning and draw conclusions based on the existing text in documents (Charmaz & Belgrave, 2007). This approach was considered appropriate for the study to conduct desktop research by collecting data from secondary sources such as online

academic articles and theses, reviews and reports. A three-stage process was followed to answer the study's research questions as illustrated in Figure 2.1:

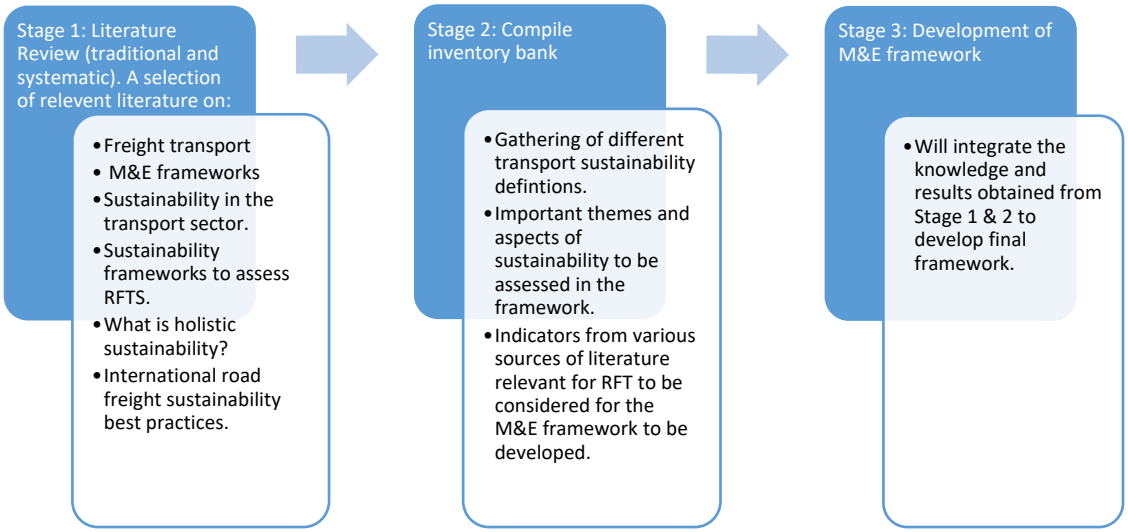


Figure 2.1: Sequential research design breakdown (Stage 1-3)

Stage 1: The method used in stage one was a combination of a traditional literature review and a systematic literature review. Research questions one, four and five were answered using the traditional literature review method. Whereas research questions two and three were responded to using a systematic literature review. The search phrases used to collect secondary data including the protocols on selecting the literature to be used in answering the research questions through the systematic literature review (SLR) are detailed in Chapter 3.

Stage 2: This stage collected Key Performance Indicators (KPIs) to be categorised within their relevant sustainability dimensions. The study adapted the structure of Toth-Szabo and Varhelyi's (2012) sustainability framework as a template for developing the M&E sustainability assessment framework for road freight transport systems (RFTS) in South Africa. The structure assisted in assigning the goals/objectives, inputs, outputs, and measures concerning the selected sustainability themes to be used in the M&E sustainability assessment framework developed in the current study.

Stage 3: The findings from research questions 1, 2, 3 & 5 informs the aspects integrated into the M&E sustainability assessment framework, taking into consideration importance and relevance.

The methodological approach employed in this study was mixed methods that consisted of predominately qualitative methods to answer the research questions. Figure 1.1 illustrates the

qualitative research methods used in the reviews of literature following a thematic content analysis used to explore topics and constructs of the research.

Quantitative methods were also employed, to gather frequencies and test the hypothesis in RQ1 and also in the form of the bibliometric statistics of the SLR. The survey used as part of RQ4 consisted for both quantitative and qualitative methods.

A top-down approach also known as deductive reasoning was applied in this study. This approach begins with a broad idea and works towards narrowing it to specific conclusions (Wilhelm, 2005). Moreover, the approach is said to reliably produce logically and realistically true statements (Johnson-Laird, 1999; Sternberg, 2009).

2.4 Data collection

A combination of different methods were employed to collect data. Firstly, secondary data were collected through a traditional literature review (TLR) and a systematic literature review (SLR). In addition, content analysis and synthesis tables were used to review the current schools of thought around M&E frameworks and sustainability linked to road freight transport systems. This assisted in proposing and developing a robust M&E framework for the sustainability assessment of RTFS in South Africa. Scholarly and scientific data were sourced mainly from search engines like Google, Google Scholar, Science Direct, Web of Science and Scopus.

2.5 Data analysis

The literature investigation for RQ 1 assisted in forging together an operational definition for the study. Additional tools used in stage 1, specifically for RQ 1, which sought to investigate sustainability and how it is defined in the transport sector; included content analysis coupled with term and theme frequencies. Atlas.ti 8 computer software aided this analysis. Additionally, data were exported from the Atlas.ti 8 software to Microsoft Excel for further analysis. Also, RQ 2's bibliometric data from Scopus and Web of Science were exported to Microsoft Excel for further analysis.

2.6 Validity and Reliability of results

Ensuring the validity and reliability of data collection instruments is important to ensure that the aim of the study is fulfilled and study findings are credible. Three internal validity types and one reliability type were used in the present study for this purpose. Validity examines how accurate an instrument measures the findings of the research (Moskal & Leydens, 2000; Heale, & Twycross, 2015), whereas reliability looks at the integrity of the results produced, and consistence in the study findings (Moskal, and Leydens, 2000).

2.6.1 Validity

Three validity types were used in this study in two instances. Firstly, to define sustainability in the transport sector, and secondly, to validate measures selected for the final M&E sustainability assessment framework. *Content validity* determines how well an instrument covers the range of meaning about the concept being covered. Content validity was done for *research question 1: How is sustainability defined in the road freight transport sector?* by ensuring that definitions across various freight transport stakeholders were evaluated. *Criterion validity* is used to predict or relate to an external variable from the results and *Construct validity* analyses the accuracy of a construct. These two latter types were used in developing the framework, for example, if the construct seeks to evaluate time, then the measure selected should have a time variable to be measured. The measures in the developed framework related to external variables in the sustainability assessment and were selected based on construct validity to ensure what is being measured related back to the goals or inputs or outputs within the framework.

2.6.2 Reliability

An inter-rater reliability check was used to rate the developed M&E sustainability assessment framework in this study. This type of reliability checked the consistency in rating (Saal, Downey & Lahey, 1980). It is a useful assessment tool, particularly in judging activities conducted by humans (Landis & Koch, 1977). Several industry experts were requested to review the developed M&E sustainability assessment framework through a survey, to validate the relevance and credibility of the sustainability framework for RFTS in South Africa. The ratings were compared to determine consistency in the raters' feedback.

2.7 Scope and Limitations of the study

The scope of this study was to develop an M&E sustainability assessment framework. Topics on sustainability, freight transport systems, and monitoring and evaluation as well as the main focus of the study on the sustainability of RFTS were discussed. Time constraints, limited the scope of research to solely focus on developing an M&E sustainability assessment framework for RFTS. The study excluded passenger road transport and other modes of transport; namely air, sea, rail and pipeline transport. Lastly, the framework focused on the context of the South African transport industry. As such, the applicability of the framework to non-South African contexts is limited.

2.8 Confidentiality and research ethics

This study is a low risk, as it is centred mainly on secondary data. This research approach focused on extracting new meaning or a deeper understanding of knowledge already available and published in the public domain. Therefore, the data collected did not include sensitive information that could be harmful to the reputation of humans, animals, or organisations.

With regard to the survey questionnaire used to review the M&E sustainability assessment framework by industry experts, participation in the validation process was voluntary and sharing of personal information by participants was not compulsory. Moreover, names of the participants were not used in the study, number codes were used instead. Only information linked to their work background was shared to prove the relevance of their review submissions in the study.

2.9 Conclusion

The chapter focused on the methodology used in the study. A combination of qualitative and quantitative research methods, and data collection techniques was followed in this study. This enabled the solicitation of data from literature sources of different academic databases, namely: Scopus, Science Direct, Google Scholar, Web of Science and EBSCO Host. The study followed grounded theory where conclusions were drawn from existing text. The design process consisted of three stages to facilitate the objectives of the study. A validation process for the developed M&E sustainability assessment framework was undertaken though using a survey to ensure validity and reliability of results. The scope and limitations of the study clarified that only road freight transport, the three pillars of sustainability and the South Africa context provides as the focus of the study.

CHAPTER 3: LITERATURE REVIEW

3.1 Introduction

The discussions in this chapter follow the traditional literature review method. Data is explored to answer research questions specifically, one and five. The literature review was used specifically for concept clarification on freight transport (section 3.2), monitoring and evaluation (section 3.3) and sustainability (section 3.5). The traditional literature review method was also used to collect data on road freight transport best practices (section 3.4). Grounded theory was used to sort and interpret the data.

3.2 Freight transport

The transport sector renders a service of which the outcome is the conveyance of goods from point of trip origin to destination. The goods transported range along with a variety of dimensions, forms, masses and sizes (Reis, & Macário, 2019). These goods, generally used for commercial gain, are referred to as freight (McLeod, Schapper, Curtis, & Graham, 2019).

Freight transport can be defined as the movement of goods, the physical process of transporting merchandise, commodities, and cargo. Freight transportation operations are known to predominately be made by air, sea, road, rail, or a combination thereof, between station points, cities, and across long distances (Rodrigue, 2020). The demand for freight transport is derived from consumer's desire all around the world to purchase goods supplied at various locations (Profillidis & Botzoris, 2018).

Freight transportation is a key element of all supply chain and logistics systems (Ranaiefar & Regan, 2011) and is a necessary component for economic development. Rajabi (2011) describes the role freight transport plays as supporting the activities of manufacturing, trade, and consumption as vital. Global economic systems have changed as freight networks became more interconnected, growing supply chains and freight flows (Rodrigue, 2004; Rodrigue & Notteboom, 2009; Lam &Yap, 2011).

The growth trend of freight transport has favoured road since its deregulation, with the prediction that road freight will continue to enjoy increased traffic flows. For other modes of transport to compete with road transport's door-to-door attractiveness, the focus needs to be on offering a higher degree of reliability, more frequent schedules, and reduced transit turnaround times (Lowe, 2006; McKinnon, 2006).

There has been a shift from rail to road globally. Many countries have seen the migration of freight carried inland by rail move to road freight transport (McCarthy, 1999; Kaack, Vaishnav, Morgan, & Azevedo, 2018; Liimatainen, Pöllänen, & Nykänen, 2020). This has consequently come with adverse bearings on the society, economy, and environment: such as congested roads, reduced mobility, road causalities, and air pollution. To counter this, several regulations and initiatives have been introduced to reduce the negative impact of freight vehicles. Intermodal integration is the most widely advocated for, with the view that it is the solution towards sustainability in freight transportation (Behrends, 2011; Popović, Lazarević, Vukićević, Vilotijević &Mirković, 2017; Liu, Mu & Gong, 2017; van Wee, Kamargianni, & Shiftan, 2018).

3.3 Monitoring and evaluation

Monitoring and evaluation is a function of project management that allows an open viewpoint to any changes made in a project implementation process (Onyango, 2019). It is useful to have M&E included from the pre-project stage as it gives project teams and managers' continuous feedback for decision making, even before the project evaluation at the final stage of the project is conducted (Tache, 2011).

In the process of developing a project with the ability to meet the desired results, M&E systems and workflows should be considered (Yaghootkar and Gil, 2011). In a nutshell, M&E is the basic tool used to handle complex projects (Dobrea, Ciocoiu & Tipa, 2010). In the wider spectrum of project planning and implementation, M&E is key.

The process of monitoring can be regarded as support for evaluation. It enhances and emphasizes the quality of the assessment. Although complementary, the two concepts seek to ask different questions and hence are considered separately (Pollack, 2007). Monitoring is the ongoing activity of observing and recording outputs/results. It is mainly tracked by the functional level of management, such as supervisors and line managers. The activity is usually short-term and mainly focused on collecting data at specific pointers of day-to-day activities. Its nature is observational, implemented to provide early indicators of the degree of progress, change, development, or the lack thereof to stakeholders (Onyango, 2019).

Evaluation, on the other hand, is a periodic activity performed by managers to critically assess the outcomes of the impact of a project or system against the planned objectives. The process of evaluation requires comprehension of the outcomes to determine the implications,

effectiveness, and success of the project or system. Critical judgments and validations need to be made when evaluating (Onyango, 2019).

Monitoring and evaluation go beyond the eminence of inputs and outputs but consider the results and impact of the initialised project or system (Kusek & Rist, 2004). The M&E framework is a reflective process designed to assist in learning from experience (Crawford & Bryce, 2003). The effects of the implemented changes and mechanisms for adapting can be furnished by M&E frameworks (Cathy, 2011).

3.4 Road freight best practices

Best practices are found within different fields, within communities of practice. The World Health Organisation (WHO) (2017) defines best practices as methods or techniques that have been reliably proven through research and experience to produce a desired result. In some communities of practice, there is mention of good practices rather than best practices, due to the assumption that one cannot improve beyond the superlative "best". Furthermore, "best" concerning best practices should not be viewed in the superlative. The WHO continues to state that best practices are not a state of perfection or pronouncing those practices to be the only practices that lead to successful interventions. Nonetheless, a good practice similar to a best practice is an intervention that has been tested and validated as successful in producing good results and, therefore, endorsed as a model (FAO, 2013).

The American Production and Inventory Control Society's, Supply Chain Operations Reference Model defines best practices as methods that are current, structured, and known in a broad sense as superior to alternatives repeatedly yielding favourable results on supply chain performance (Syrzysko, 2006). Such practices should be documented and shared so that other participants within that community of practice can adopt and adapt best practices that fit their context. Furthermore, doing such is critical for self-assessment or benchmarking (Bogan, 1994). To be coined best practices for a field, there is a consensus or adaptation of the methods and techniques within the field. The focus of this study is on internationally applicable and locally relevant best practices for road freight sustainability. Generally, sustainability in road freight transport aims at creating synergies, complementarities, and coherence in the sector by the integration of balanced social, economic, and environmental practices.

Road freight sustainability best practices bring about systems that are accessible, safe, fuel-efficient, environmentally friendly, and resilient to shocks and disruptions (United Nations Conference on Trade and Development (UNCTAD), 2015). There are several countries with

road systems that have sophisticated networks as well as the features described by UNCTAD (2015). The United Arab Emirates, Hong Kong, Japan, France, the United States of America, and Austria are some of the countries in this category. One key feature of these countries is their high-quality, developed road systems that are well planned and maintained. The World Economic Forum's global competitiveness report (2018) ranked Singapore, Switzerland, and Netherlands as the top three countries in terms of their road network quality and connectedness (Van de Pas, 2018).

Concerning road infrastructure and connectivity, South Africa has developed one of the most advanced transport infrastructures in the African region (World Economic Forum, 2019). Figure 3.1 displays countries with the highest-ranked road quality and road connectivity. South Africa appears in the top five categories for road connectivity. In terms of the Logistics Performance Index (LPI) (2018), Germany, Sweden, and Belgium were ranked as the top three countries; with South Africa ranked at number 33 out of 160 countries. From these rankings, South Africa's performance is not dismal, but there is room for improvement. Improved management of its existing practices in the field of road freight transport and the adoption of best practices within the field could see the country accumulating higher scores and even potentially creating more sustainable road freight systems.

Figure 3.1: Ranking of countries road quality and connectivity

Source: Statista infographics (2018)

Best practice entails moving beyond compliance to seeing how one's transport system can influence improved and more sustainable outcomes. The countries listed above have addressed road freight infrastructural needs and capacity of the successful movement of road freight, as well as creating networks that exceed merely meeting the standard. Table 3.1 comprises a list of best practices used in the road freight transport community.

Table 3.1: Examples of relevant sustainability-motivated best practices

Type of intervention measures and actions	***Example of measures and actions***
Technology and innovation	- Intelligent transportation systems; - Fleet management software; - Intelligent logistics solutions (e.g. optimization of e-freight initiatives); - Electronic devices for monitoring engines; - Vehicles safety features; - Computers to measure fuel efficiency (e.g. Eco-driving); - Computerized routing and scheduling; - Software with GPS; - RFID tracing; - Software to alert drivers to the most cost-effective fuelling locations; - Devices that automatically switch off idling engines; - Use of cleaner land-based cargo-handling equipment (such as IT-driven quay cranes and eco-friendly rubber-tyred gantry cranes).
Fuel-related measures	- Use cleaner fuels, cleaner-burning engines; - Improve vehicle and propulsion technology; - Invest in energy efficiency, wide-base tyres to increase rolling resistance, and more aerodynamic design to improve fuel efficiency; - Adopt efficient routing practices, reduce idle time, and reduce speed.
Economic measures	Create a more optimal freight transportation market by reforming transport prices and investment practices, apply full-cost pricing, congestion pricing, carbon pricing, taxation, grants, and subsidies (e.g. to speed up old engine turnover).
Modal shift	Intermodal and non-modal shipments as applicable and feasible. Promote through a set of economic, regulatory, and market measures a shift toward less energy-intensive/carbon-intensive modes (e.g. from the road to rail, short sea shipping, and inland waterways).
Land use	Improve land use planning, change land use patterns to reduce travel distances and increase mode choice, port-centric logistics, use co-, and intra-modal hubs to free land resources.
Strategic and operational	- Restructure the physical logistics network, locating manufacturing sites and/or warehousing facilities close to major customer concentrations and/or supply bases; - Plan and organize routings and scheduling to reduce empty mileage and optimize operations; - Shared/grouped consignments for load efficiency; - Promote links between different modes of transport to make more efficient use of existing infrastructure; - Fleet renewal plan.

Type of intervention measures and actions	*Example of measures and actions*
Regulatory	- National laws on heavy vehicles; - Emissions standards; - Design of vehicles and infrastructure; - Speed limits; - Industry-led and government accreditation schemes and standards; - Targets for use of renewable energy sources; - Targets for energy efficiency, emissions, and noise standards for vehicles; - Requirement for integrated transport and land-use strategies; - Traffic restrictions.
Other/soft measures	- Adoption of new packaging methods (e.g. reducing package size to the optimal size and weight for the contents, eliminate unnecessary packaging layers, and using more sustainable material); - Training programmes (e.g. driving techniques that maximize fuel efficiency), awareness-raising activities, enable greater access to information and communication technology; - Shared responsibility by industry, government, and end-users.

Source: Adapted from UNCTAD, based on a literature review from NRSPP & Michael Holmes, 2020; Ruamsook and Thomchick, 2012

Table 3.1 provides multiple types of interventions that can be considered for implementation in road transport systems. Adaptation of the best practice actions depends on several factors such as the context, the will of the road freight system role-players, capital costs or inputs, time, and institutional requirements (for instance, policy; infrastructure; subsidies, and incentives).

Several role-players are key to creating sustainable road freight systems. These include: local authorities, which are part of the government as they are predominately responsible for the built environment in which road freight transporters operate; freight producers and road freight transporters, as well as the consumers that drive the market. To create a sustainable road freight system, a unified effort from all stakeholders is vital (Quak, 2012). Another argument from Quak (2012) is that road transporters have integrated many best-practice initiatives into their systems. Their efforts are not seen due to the difference in scope between them and the other roleplayers. The transporters' efforts are at times overlooked because their initiatives tend to be internal to their supply chains and hence do not attract the same attention as the local authorities whose efforts of sustainability best practices are public.

In the community of road freight transport, there is action from industry, and governments around the world. There is also an abundance of research around logistics/supply chain, business strategy, policy, and technological system solutions for more stakeholders who want to participate or implement supplementary best practice initiatives. Effort is needed from all stakeholders in the pursuit of making road freight transport more efficient and sustainable.

3.5 Sustainability

The term “sustainability” is frequently used by the public in political and business dialogue. The Brundtland Report of 1987 (also known as ‘Our Common Future’) popularised the concept of “sustainability”. This report was compiled by several countries for the United Nations, to advance sustainable development (McChesney, 1991).

What stands out from ‘Our Common Future’ is the emphasis on possible social, economic, and environmental cohesion and its necessity. It also includes discussions around the application of sustainable solutions on some issues such as biodiversity, agriculture, population, energy choices, and industry (Du Pisani, 2006).

The debate around sustainability has evolved to not solely discuss environmental concerns but to incorporate social and economic issues as focal areas of sustainability (Dempsey, Bramley, Power & Brown, 2011). These three approaches are the most widely accepted lenses through which sustainability is viewed. The three tend to be inter-related and correspond to one another. Doane and MacGillivray (2001) generally summed up the notion of sustainability as something with the ability to continue endlessly, and something that cannot continue endlessly being unsustainable.

3.5.1 Exploring the origins of the concept of sustainability

The origins of the concept of sustainability can be said to hinge on the forestry industry. John Evelyn, an English intellect, reflects a sense of necessity to utilise wood consciously, warning against careless deforestation and advocating for the replanting of trees in England in his book ‘Sylva, or A Discourse of Forest-Trees and the Propagation of Timber in His Majesty's Dominions’ commissioned by the Royal Society and published in 1664. His work is recognised as one of the most influential publications on forestry (Johnston, Grayson & Bradley, 1967). In 1713, mines Director Hanns Carl von Carlowitz began to lay the foundation of the concept of sustainability as proposed in his book, the rule for forestry to be “continuirliche, beständige und nachhaltende Nutzung” translated to continuous, permanent and sustainable utilisation (Huuri, Huuri & Oja, 1989; Vehkamäki, 2005).

During the 17th and 18th centuries, several major changes occurred in European thought. This period was known as the Age of Enlightenment. The Age saw many discoveries, wars of religion, colonisation and the exploitation of resources in newly-discovered foreign lands (Vehkamäki, 2005). Du-Pisani (2006) accounts for the emergence of sustainable development during the mid-1900s to be due to the collapse of military alliances and great colonial powers.

Harris (2000) believes that the end of World War II, in particular, brought attention to the concept of sustainability as it exposed how destructive mankind can be to the natural environment (Bani-Khalid, 2019).

Following World War II, developing countries around the world were anticipated to be characterised by a combination of poverty, deforestation, soil erosion, and degradation. The Western world believed international intervention would be needed to mitigate increasing inequality, limited resources, and environmental problems (Arndt, 1989). 'Silent Spring' by Carson (1962), the 1969 oil spill in Santa Barbara as well as the publication, The Ecologist's 'A Blueprint for Survival' (1972) intensified awareness of the environmental ruin caused by mankind (Purvis, Mao & Robinson, 2019). In 1972, the first global summit, the Human–Environment was held in Stockholm. The summit raised the importance of environmentally sound development to be considered with economic development (Caldwell, 1984).

By the 1980s, ecological movements had slowed down, and reforming socialism together with economic development critiques begun to incorporate social and environmental considerations into the concept of sustainability (Van Der Heijden, 1999). 'Our Common Future' also known as the Brundtland Report complied in 1987 brought a holistic approach, namely environmental, social, and economic dimensions to the concept of sustainability/sustainable development as we understand it today (Imperatives, 1987; Purvis, Mao & Robinson, 2019).

3.5.2 The three pillars/dimensions of sustainability

The origins of sustainability in development are found to lie within ecological concerns. Consequently, the environmental dimension has been the most frequently discussed (Soini & Birkeland, 2014). However, as explored, the concept of sustainability has evolved to not solely discuss environmental concerns, but also to incorporate social and economic issues as focal areas of sustainability (Dempsey *et al.* 2011). These three approaches are the most widely accepted lens through which sustainability is viewed. The three are inter-related and correspond to one another. Figure 3.2 shows sustainability as a commonly seen illustration in the form of a 'Venn diagram' in academic and non-academic literature or a three-pillar paradigm (Purvis *et. al.* 2019).

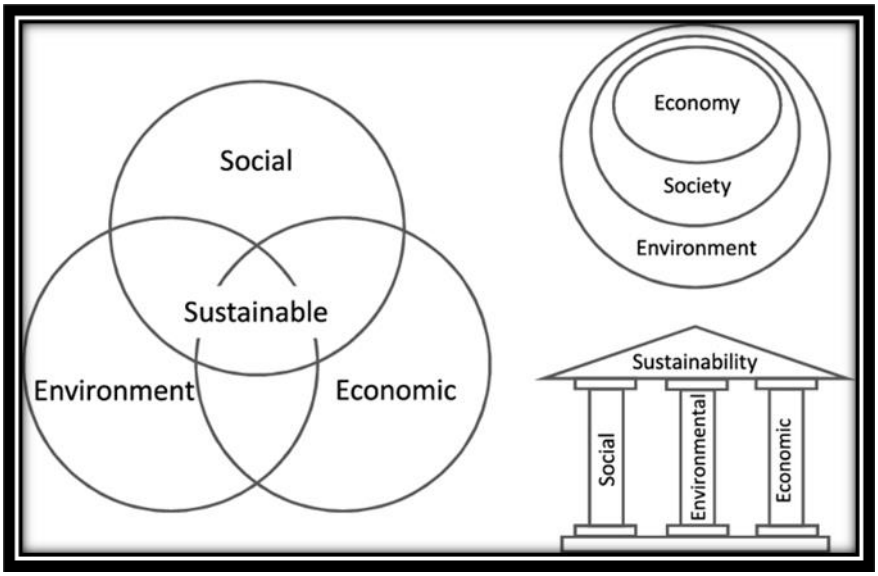


Figure 3.2: Social, Environment and Economic dimensions intertwine as sustainability

Source: Purvis et al., 2019

Figure 3.2 illustrates the 'common view' in which the relationships between the three dimensions of sustainability are often found. The dispute on the common illustrations is that there has been no detailed theoretical development on the conceptualisation of any of the diagrams in Figure 3.2. As a result, Giddings, Hopwood, and O'brien, (2002) supported by Thomson (2017) note that proposed theories on this phenomenon fail at face value to offer a comprehensive understanding of how each dimension in itself or together translate into sustainability.

3.5.2.1 Social sustainability

Social sustainability is a concept that links to an extensive range of similar ideas such as social equity, social cohesion, and distributive justice. The concept may further transform over time to meet a future society's idea of social sustainability (Dempsey *et al.* 2011).

Many authors argue that the human dimension of sustainability is the least developed aspect of sustainability and has not received adequate attention in public dialogue compared environmental and economic sustainability (Omann, & Spangenberg, 2002; Magis & Shinn, 2008; Vallance, Perkins & Dixon, 2011). Boström (2012) asserts that some effort has been made to define and develop the social dimension in sustainability practices, projects, and initiatives.

Social sustainability is concerned with recognizing and managing the positive and negative impacts of business on humanity. The foundations of social sustainability are human rights. Although the issue of human rights is mainly a governmental affair, businesses and other stakeholders should make contributions towards social sustainability (UN Global Compacts, n.d).

3.5.2.2 Economic sustainability

Economic sustainability is a prominent aspect of policy debate. Very often decision- and policymakers weigh the other two sustainability dimensions against the economic viability of a proposed change. Surprisingly, although ideas can be found in economic literature on environmental and social sustainability with regard to the economic dimension, there is limited literature on the "economic sustainability of the economy" (Spangenberg, 2005).

Economics is conventionally known to concern itself with how scarce resources are allocated (Hakes & Tennant, 2009). Sustainability in the context of economics should ensure companies and organisations are managed in such a way that they remain in business, standing the test of time. Furthermore, economic sustainability can be outlined as the process of allocating and preserving scarce resources, while ensuring they are not depleted at the expense of future generations (Doane & MacGillivray, 2001).

In light of economic sustainability, many businesses are not yet persuaded to pursue social and environmental competencies as the economic argument may not yet be sufficiently compelling. Hence, sustainability is currently optional for many organisations. It has not yet become a crucial necessity for the immediate survival of organisations. For the long-lasting survival of businesses, the importance of environment and social sustainability should be emphasised and acknowledged by businesses (Doane & MacGillivray, 2001).

3.5.2.3 Environmental sustainability

Environmental sustainability refers to maintaining or improving the life systems of the physical environment (Sutton, 2004; Moldan, Janoušková & Hák, 2012). This aspect of sustainability has received significant global attention due to the negative environmental effects that the world is experiencing such as Global Warming/ Climate Change. These environmental issues have adverse trickling effects on social wellbeing and economies. Environmental problems occur on land, water, in the air and are caused either by human activities and/or natural disasters (Kendirli, Gunes & Basaran, 2014).

Significant contributors to environmental unsustainability are industrialisation, urbanisation, and population growth (Kaya, 2006). The excessive release of carbon dioxide (CO_2) from manufacturers, power plants, and other sources fuel the effects of the Earth's life cycle and climate change (Al-Maamary, Kazem & Chaichan, 2017). In order to conserve the environment, action needs to be taken towards environmental sustainability.

3.6 Defining sustainability in the transport sector

Defining sustainability in the transport sector is a complex and challenging task. The literature reviewed indicates that there are as many definitions as people who are writing on the subject. The dominant influence has largely been the author's perspective and approach to sustainability that impacts how sustainability is defined in the transport sector. This study focuses on definitions in Table 3.2 that contribute to describing either social, economic, or environmental notions and those that cover all three dimensions of the Triple Bottom Line (TBL), which are environment, economic and social considerations.

Table 3.2: Synthesis table of sustainable transport definitions and term frequencies

Author	Year	Definition	Access	Safety	Affordable	Modal Choice	Fair & Equitable	Cost	Emission	Renewable	Noise	Future or Generations	Development or Infrastructure
Brundtland Commission	1987	Sustainable development "meets the needs of the present without compromising the ability of future generations to meet their own needs."										x	x
Herman E. Daly and D.W. Pearce, et al.	1992 & 1993	"Transport and mobility with non-declining capital, where the capital includes human capital, monetary capital, and natural capital."											
Black	1996	"Transport that meets the current transport and mobility needs without compromising the ability of future generations to meet these needs."										x	
Lee Schipper	1996	Sustainable transport is transportation where the beneficiaries pay their full social						x				x	

Author	Year	Definition	Access	Safety	Affordable	Modal Choice	Fair & Equitable	Cost	Emission	Renewable	Noise	Future or Generations	Development or Infrastructure
		costs, including those that would be paid by future generations.											
Transportation Research Board (TRB)	1997	"…sustainability is not about threat analysis; sustainability is about systems analysis. Specifically, it is about how environmental, economic, and social systems interact to their mutual advantage or disadvantage at various space-based scales of operation."											
Toronto-based Centre for Sustainable Transportation used by the Ministers of Transport of the 15 European Union countries.	1997	A sustainable transportation system is one that: -Allows the basic access needs of individuals and societies to be met safely and in a manner consistent with human and ecosystem health, and with equity within and between generations.	x	x	x	x	x		x	x	x	x	

Author	Year	Definition	Access	Safety	Affordable	Modal Choice	Fair & Equitable	Cost	Emission	Renewable	Noise	Future or Generations	Development or Infrastructure
		-Is affordable, operates efficiently, offers a choice of transport mode, and supports a vibrant economy. -Limits emissions and waste within the planet's ability to absorb them, minimizes consumption of non-renewable resources, limits consumption of renewable resources to the sustainable yield level, reuses and recycles its components, and minimizes the use of land and the production of noise.											
Centre for Sustainable Transportation	1998	Allows the basic needs of individuals and societies to be met safely and in a manner, consistent with human and ecosystem health, with equity within and between generations; is affordable, operates efficiently, offers the choice of transport mode and supports a vibrant economy; limits emissions and waste within the		x	x	x	x		x	x	x	x	

Author	Year	Definition	Access	Safety	Affordable	Modal Choice	Fair & Equitable	Cost	Emission	Renewable	Noise	Future or Generations	Development or Infrastructure
		planet's ability to absorb them, minimizes consumption of non-renewable resources, reuses and recycles its components and minimizes the use of land and production of noise.											
Richardson	1999	A sustainable transportation system is "one in which fuel consumption, vehicle emissions, safety, congestion, and social and economic access are of such levels that they can be sustained into the indefinite future without causing great or irreparable harm to future generations of people throughout the world."	x	x			x		x			x	
Transport Canada	1999	"The goal of sustainable transportation is to ensure that environmental, social, and economic considerations are factored into decisions affecting transportation activity."											

Author	Year	Definition	Access	Safety	Affordable	Modal Choice	Fair & Equitable	Cost	Emission	Renewable	Noise	Future or Generations	Development or Infrastructure
Mobility report (MIT and Charles River Associates)	2001	"The ability to meet the needs of society to move freely, gain access, communicate, trade and establish relationships without sacrificing other essential human or ecological values today or in the future."	x									x	
European Conference of Ministers of Transport (ECMT)	2004	A sustainable transport system is one that is accessible, safe, environmentally-friendly and affordable.	x	x	x								
Centre for Sustainable Transport (CST)	2005	A more sustainable transportation system is one that: - Allows the basic access and development needs of people to be met safely and promotes equity within and between successive generations (Social dimension).	x	x	x		x	x	x		x	x	x

Author	Year	Definition	Access	Safety	Affordable	Modal Choice	Fair & Equitable	Cost	Emission	Renewable	Noise	Future or Generations	Development or Infrastructure
		- Is affordable within the limits imposed by internalization of external costs, operates fairly and efficiently, and fosters a balanced regional development (Economic dimension). - Limits emissions of air pollution and GHGs as well as waste and minimises the impact on the use of land and the generation of noise (Environmental dimension). - Is designed in a participatory process, which involves relevant stakeholders in all parts of the society (Degree of participation).											
Centre for Environmenta Excellence by the American Association of State Highway and	2009	Economy — Support economic vitality while developing infrastructure in a cost-efficient manner. Costs of infrastructure must be within a society's ability and willingness to pay. User costs, including private costs, need to be	x	x		x		x	x				x

Author	Year	Definition	Access	Safety	Affordable	Modal Choice	Fair & Equitable	Cost	Emission	Renewable	Noise	Future or Generations	Development or Infrastructure
Transportation Officials (AASHTO)		within the ability of people and households to pay for success. Social — Meet social needs by making transportation accessible, safe, and secure; include the provision of mobility choices for all people (including people with economic disadvantages) and develop infrastructure that is an asset to communities. Environment — Create solutions that are compatible with - and that can be an enhancement to - the natural environment, reduce emissions and pollution from the transportation system and reduce the material resources required to support transportation.											
Dalkmann and Huizenga	2010	One that has "low-carbon, sustainable transport reduces short and long term negative impacts on the local and global environments,	x	x									x

Author	Year	Definition	Access	Safety	Affordable	Modal Choice	Fair & Equitable	Cost	Emission	Renewable	Noise	Future or Generations	Development or Infrastructure
		has economically viable infrastructure and operation, and provides safe and secure access for both persons and goods."											
United Nations Environment Programme (UNEP)	2011	Green transport is defined as support for environmental sustainability through e.g. the protection of the global climate, ecosystems, public health, and natural resources. It also supports the other pillars of sustainable development, namely economic (affordable, fair, and efficient transport that engenders a sustainable competitive economy, as well as balanced regional development and the creation of decent jobs) and social (e.g. allowing basic access and the development needs of individuals, companies, and society to be met safely and in a manner consistent with human and ecosystem health,	x	x	x		x					x	x

Author	Year	Definition	Access	Safety	Affordable	Modal Choice	Fair & Equitable	Cost	Emission	Renewable	Noise	Future or Generations	Development or Infrastructure
		and promoting poverty reduction, equality, and equity within and between successive generations).											
Organization for Economic Co-operation and Development (OECD)	2017	The Environmental Directorate of the OECD defines environmentally sustainable transportation as, "transportation that does not endanger public health or ecosystems and that meets needs for access consistent with (a) use of renewable resources that are below their rates of regeneration, and (b) use of non-renewable resources below the rates of development of renewable substitutes."	x							x			x
Total Frequency			9	8	5	3	2	3	5	3	3	9	6

3.6.1 Key terms and themes found in the definitions

In analysing the various definitions, there are commonly reoccurring terms used to describe sustainability in the transport sector. Table 3.2 provides a list of terms that are found across the definitions used in this study. The most frequently cited term was “access” and “future or generation” which appeared nine times out of the 16 definitions, followed by safety, which appeared eight times and then “infrastructure or development” followed with a frequency of six. It was further observed that merely counting the frequencies of the individual term would not be sufficient or the most appropriate method to sift or capture the dominant ideas that are used in describing sustainability in the transport sector from the definitions, as there are other terms used by the authors to describe similar if not the same concepts, which would not be accounted for if only individual terms were considered.

As a result, themes were created and used to code terms, phrases, and ideas that speak to the reoccurring concepts and ideas that were found across the definitions. Table 3.3 contains eleven themes that were used to code the definition in the data analysis software Atlas.ti 8. The number of phrases and terms that were found to describe sustainability in the transport sector through the themes were tallied and summed (Table 3.3). *Ecological and Geographical Impact* ranked as the most dominant mention across all the definitions. Ranked at second highest in frequency were both the *Preservation for Future Generations* and *Socio-economic* themes. The theme that was least mentioned was *Government & Community Involvement*, which was captured in only one definition.

Table 3.3 Theme frequencies

Rank	**Theme**	***f***	**Coded phrases and terms**
1.	Ecological & Geographical Impact	14	Environmental (x3), environment(s) (x3) ecosystem health (x4), natural capital (x1), natural environment (x1), land (x2)
2.	Preservation for the Future	13	Equity between generation (x4), operates fairly (x2), reuses and recycles its components (x2), meeting present needs with compromising the future (x5)

3.	Socio-economic	13	Social and economic access (x1), social systems (x2), human capital (x1), trade and establish relationships (x1), basic needs of individuals and societies developed (x6), poverty reduction (x1), social considerations (x1)
4.	Economic Productivity of the System	10	Supporting a vibrant economy (x4), operational efficiencies (x3), economic (x3)
5.	Transport Resource Consumption	8	Minimize consumption of renewable resources (x5), fuel consumption (x1), non-declining capital (x1), minimising land use (x1)
6.	Safety & Security	8	Safety/safely (x7), secure(x1)
7.	Accessibility & Availability	9	Basic access (x3), accessible (x2), meeting needs for access (x2), gain access (x1), access for both persons and goods (x1)
8.	Financial perspective	8	Is affordable (x5), beneficiaries pay their full social cost (x1), monetary capital (x1), cost-efficient manner (x1)
9.	Pollution	7	Vehicle emissions (x1), limit/reduce emission and waste (x4), low carbon (x1), production of noise (x1)
10.	Mobility	4	Move freely (x1), offers choice of transport mode (x3)
11.	Government & Community Involvement	1	Designed in a participatory process (x1)

Through content analysis of term frequencies and reoccurring themes, it was identified that the focus of defining sustainability in the transport sector leans towards environmental protection. Efforts and solutions are focused on minimising the negative impact posed on ecosystems and the promotion of fostering a healthy environment. The themes that relate to issues that the environmental dimension of sustainability advocates for (Ecological & Geographical Impact, Transport Resource Consumption, and Pollution) altogether were referenced 29 times, surpassing the themes that speak for the economic and social dimensions. This does not come as a surprise as the concept of sustainability was first initialised regarding the scarcity of resources with efforts to protect forests and wildlife (Vehkamäki, 2005; Bani-Khalid, 2019) and later developed to incorporate the social and economic dimensions (Vehkamäki, 2005; Dempsey *et al.* 2011), which are areas that transport stakeholders should not neglect.

3.6.2 Statistical analysis of the definitions and key terms

The study sought to establish whether there is a relationship between the key terms and definitions. The statistical method to determine a relationship between two nominal variables (name, label, or category) being measured is a contingency table also known as cross-tabulation (Ferguson, 1987). The two categorical variables, namely the author definitions and the key terms found in Table 3.2, were cross-tabulated with the appropriate row percentages in Table 3.4.

Table 3.4: Contingency table of definition numbers and key terms

	2-Way Summary Table: Observed Frequencies (Term HQ1 in DATA 20200608) Marked cells have counts > 10											
Definition number	Key terms Access	Key terms Safety	Key terms Affordable	Key terms Modal Choice	Key terms Fair & Equitable	Key terms Cost	Key terms Emission	Key terms Renewable	Key terms Noise	Key terms Future/Generations	Key terms Development/Infrastructure	Row Totals
1	0	0	0	0	0	0	0	0	0	1	1	2
Total %	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	1,69%	1,69%	3,39%
3	0	0	0	0	0	0	0	0	0	1	0	1
Total %	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	1,69%	0,00%	1,69%
4	0	0	0	0	0	1	0	0	0	1	0	2
Total %	0,00%	0,00%	0,00%	0,00%	0,00%	1,69%	0,00%	0,00%	0,00%	1,69%	0,00%	3,39%
6	1	1	1	1	1	0	1	1	1	1	0	9
Total %	1,69%	1,69%	1,69%	1,69%	1,69%	0,00%	1,69%	1,69%	1,69%	1,69%	0,00%	15,25%
7	0	1	1	1	1	0	1	1	1	1	0	8
Total %	0,00%	1,69%	1,69%	1,69%	1,69%	0,00%	1,69%	1,69%	1,69%	1,69%	0,00%	13,56%
8	1	1	0	0	1	0	1	0	0	1	0	5
Total %	1,69%	1,69%	0,00%	0,00%	1,69%	0,00%	1,69%	0,00%	0,00%	1,69%	0,00%	8,47%
10	1	0	0	0	0	0	0	0	0	1	0	2
Total %	1,69%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	1,69%	0,00%	3,39%
11	1	1	1	0	0	0	0	0	0	0	0	3
Total %	1,69%	1,69%	1,69%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	5,08%
12	1	1	1	0	1	1	1	0	1	1	1	9
Total %	1,69%	1,69%	1,69%	0,00%	1,69%	1,69%	1,69%	0,00%	1,69%	1,69%	1,69%	15,25%
13	1	1	0	1	0	1	1	0	0	0	1	6
Total %	1,69%	1,69%	0,00%	1,69%	0,00%	1,69%	1,69%	0,00%	0,00%	0,00%	1,69%	10,17%
14	1	1	0	0	0	0	0	0	0	0	1	3
Total %	1,69%	1,69%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	1,69%	5,08%
15	1	1	1	0	1	0	0	0	0	1	1	6
Total %	1,69%	1,69%	1,69%	0,00%	1,69%	0,00%	0,00%	0,00%	0,00%	1,69%	1,69%	10,17%
16	1	0	0	0	0	0	0	1	0	0	1	3
Total %	1,69%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	1,69%	0,00%	0,00%	1,69%	5,08%
Totals	9	8	5	3	5	3	5	3	3	9	6	59
Total %	15,25%	13,56%	8,47%	5,08%	8,47%	5,08%	8,47%	5,08%	5,08%	15,25%	10,17%	100,00%

Table 3.4 shows a contingency table extracted from the data analysis software system STATISTICA Dell Inc. (2017) version 13.2. It was revealed that one category does not influence the level of the other category. The following hypothesis was tested:

Ho: Key terms and Author definitions are independent nominal variables (unrelated)
H1: Key terms and Author definitions are dependent nominal variables (related)

The test for independence was done with suitable chi-square tests, namely Pearson's chi-square and maximum-likelihood (ML) chi-square test. The Chi-square statistical test for independence is commonly used for testing relationships between categorical variables (Ferguson, 1987). Chi-square is calculated as shown in Figure 3.3, i.e. the number of the observed frequency of the category minus the expected frequency of the category squared, divided by the expected frequency of the category.

$$\chi^2 = \frac{(Observed\ frequency - Expected\ frequency)^2}{Expected\ frequency}$$

Figure 3.3: Chi-square formula

Source: Byju's Chi-square test math article, 2021

The data for statistical analysis were first prepared in Microsoft Excel prior to importation to the data analysis software (STATISTICA Dell Inc, 2017). Table 3.2 was turned into a data sheet with all variables that were of interest (key terms) listed as columns and the author definitions category name was substituted with definition number. Thereafter, information was then ordered according to the referenced year in Table 3.2 and listed as 1-16, 1 being the 1987 definition and 16 the 2017 definition. Three author definitions from Table 3.2 contained none of the key terms namely, definition number (2, 5 & 9 being the 1992 & 1993, 1997 & 1999 definitions), and were therefore removed as there was no relationship to be tested. The data were then imported into the data analysis software system STATISTICA Dell Inc. (2017) where the Chi-square results in Table 3.5 were generated.

Table 3.5: Chi-square results and p-value for the hypothesis question

Statistic	Statistics: Definition number(13) x Key terms(11) (Term HQ1 in DATA 20200608)		
	Chi-square	df	p
Pearson Chi-square	72,19897	df=120	p=.99983
M-L Chi-square	73,06678	df=120	p=.99977

A low Chi-square value (close to 0) indicates that a relationship exists between the tested variables (Abdelmajid, 2017). The Chi-square results are far above zero. Therefore, the 13 definitions and eleven key terms analysed are unrelated. The p-value is > 0.5 and, therefore, there is insufficient statistical evidence to reject the null hypothesis. It can therefore be concluded with a 95% confidence that Key terms and Author definitions are independent nominal variables (not related), as there is insufficient statistical evidence to prove that the variables are related.

Further analysis was conducted to test the relationship between key terms and definitions through correspondence analysis for nominal variables. This analysis presented the nominal variables graphically in Figure 3.4, which provides the Definition numbers and the Key terms plotted on a graph where Key terms are in close proximity to the Definition numbers. “Proximity” between the categories as expressed in terms of the two main eigenvectors being the graph axes, visually illustrate how the categories relate to one another. The closer the positions of the key terms are to the positions of the definitions, the more the key terms are related to the definitions. Figure 3.4 shows that there is some, although trivial, relationship that exists between the definitions and key terms.

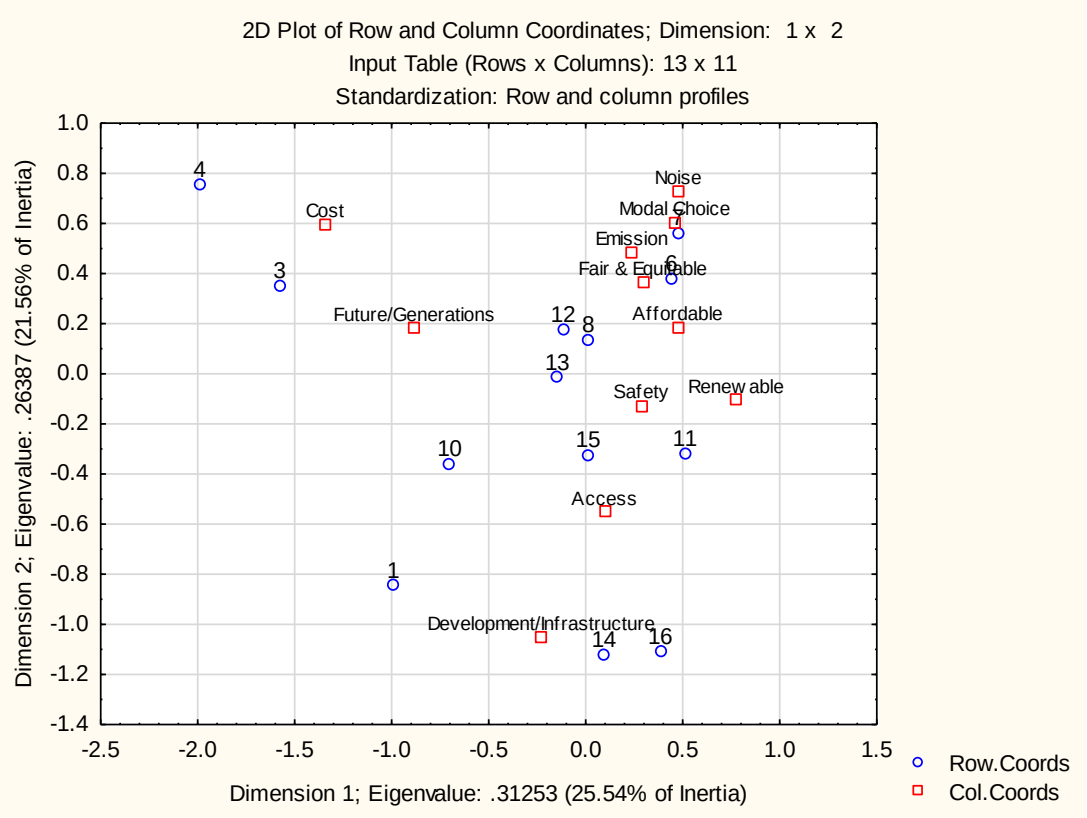


Figure 3.4: Correspondence analysis of key terms and definition numbers

3.6.3 Qualitative analysis of the definitions

Considering the definitions from a qualitative lens, most definitions in Table 3.2 are centred on the three dimensions of sustainability. Many definitions borrow their foundations from the seminal work of the Bruntland report of 1987 on sustainable development. The report defines sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". These definitions are particularly found in the theme "Preservation for the Future".

The ability to move freely and to trade is what the Mobility report's (MIT and Charles River Associates) 2001 definition highlights. Movement for trade purposes can be for a business or for individuals and is a key function of transportation referred to by many authors as a means to an end (Hillman, 1977; Tomlinson, 2011; McGimpsey & Morgan, 2013; Kudoh, 2019). This role that transport plays can be seen to support a vibrant economy, as indicated by the Toronto-based Centre for Sustainable Transportation (1997), because transportation systems provide access to life-enhancing activities for communities and bring places, people, and products closer (Veeneman & Mulley, 2018). As stated in the Centre for Sustainable Transport (CST,

2005) definition, a sustainable transport system should allow the development of people's needs to be met; as transport is what individuals use to move to and from their social activities as well as the means businesses use to position their products to consumers whether it be raw materials, labour or finished products, transport fulfils an economic concept called place utility.

In Dalkmann and Huizenga's (2010) definition, a sustainable transport system is dependent on economically viable infrastructure. Setting up the transport infrastructure in a country is a costly exercise. To have economically viable infrastructure, finances need to be secured and are raised from an array of local and international funding sources, either private or public or a combination of both, usually in the form of loan agreements (Chen and Bartle, 2017). The decision to invest in transport infrastructure is particularly difficult to make as the risk arises that financial inputs and economic benefit do not end up being synonymous. Capital investments are made with the expectation that the output results are economically viable. It is unlikely for provision to be made on a project unless the revenues compensate for the costs and that the pricing policy will be flexible to help to secure profit (Mills, 1991).

Mills (1991) further explains that where transport infrastructure cannot be appropriately charged for through suitable price mechanisms, it may make it impossible for the provider to realise favourable profit margins, and where the price mechanism used is too effective, it serves to significantly reduce the user benefits. Consequently, there is a clear dilemma that arises between having transport infrastructure that society can access in terms of affordability and being able to provide or finance the infrastructure. The Centre for Environmental Excellence by AASHTO's (2009) definition regarding infrastructure alludes to the fact that infrastructure costs should be within the society's ability to pay. When society cannot pay for a transport system, failed systems like E-toll in South Africa result as a consequence. Government, service providers, consumers and any other stakeholders need to find a balance in the price mechanism for the development of transport infrastructure to be sustainable.

The idea of fairness found in the UNEP (2011) and CST (2005) definitions imply fairness in terms of operations, but the notion of fairness in the light of sustainability in the transport sector can be interlinked with multiple ideas. For example, negative externality costs and the theme of "Preservation for the future" capture the issues where current or future generations suffer because of the actions of others, unknowingly or unwillingly. Fairness also links to the issue of access echoed in nine of the 16 definitions. Access to transport must include persons who are economically disadvantaged by being affordable (AASHTO, 2009). CST (2005) adds an

important point that transport should be affordable, but not compromising external costs that should/must be paid for by users.

Another perspective of transport costs to be paid for is found in Lee Schipper's (1996) definition. It describes transport costs as beneficiaries paying their full social cost for transport. This concept comprises of private costs; for example, fuel, oil, and travel time, and external costs. These costs are better explained by Zohrabian and Philipson (2010) to be costs imposed as a consequence of other's actions bore onto society. Examples of this are exposure to congestion, crashes, and harm to the environment via pollutant emissions not compensated for in a transport context.

The definition of sustainability in the transport sector by Richardson (1999) appeals for vehicle emissions and the consumption of natural resources to be used at levels that can be sustained indefinitely without causing harm to future generations. The American Association of State Highway and Transportation Officials (2009) supports the view in their definition as they call for the reduction of material resources needed to support transport systems. The Organization for Economic Co-operation and Development (OECD), Centre for Sustainable Transportation (CTS, 1998), and Toronto-based Centre for Sustainable Transportation (1997) advocate for consumption rates of renewable and non-renewable resources, not to be faster than their replenishment rate or rate to find renewable substitutions. The Centre for Sustainable Transportation (1998) does not only call for renewable resources to be used at sustainable yield levels but for the transport sector to reuse and recycle its components.

Defining sustainability in the transport sector is an important aspect of this study. It gives a background on how sustainability in the transport sector appears. Particular interest in this study lies on developing an M&E framework for the sustainability assessment of road freight transport systems (RFTS). Therefore, it is imperative to understand what constitutes sustainable transport systems, and what the transport industry regards as sustainability.

The operational definition for this study draws from the key terms and themes found in Table 3.2 and Table 3.3.

> *A sustainable transport system is one that is* ***accessible spatially*** *allowing* ***mobility needs*** *to be met* ***safely and affordably*** *with* ***social cost considerations*** *(private cost and cost of externalities). The system* ***operates efficiently with infrastructure*** *that is an* ***asset to communities****, offering a* ***modal choice*** *that is* ***competitive*** *and* ***boosts socio-economic development****; ensuring* ***future generations are not compromised*** *to cater to the needs of current societies. Sustainable transport* ***limits the emission*** *of air pollution, noise pollution, and GHG's.* ***It minimises the use of land****,* ***consumption of non-renewable*** *and renewable resources as well as material resources needed to support the transport system. It* ***minimises waste****, reuses, and recycles its components. It decreases its impact on the environment,* ***protecting ecosystems,*** *and the global climate. Sustainable transport systems* ***support the economic, social, and environmental pillars*** *and are designed to* ***involve stakeholders****.*

Sustainability has continually received attention over the decades. It has since developed to encompass three main focal areas namely, social, economic, and environmental dimensions. Defining sustainability in the transport sector continues to be complex, spreading across and affecting numerous disciplines. Although there is no one definition to define sustainability in the transport sector, it is evident that there are recurring themes and terms used across definitions in the literature, in which ecological issues are still prominent.

3.7 Conclusion

In summary, freight transport growth trends are noticeable in road transport. The mode is competitively appealing due to features such as door to door delivery. Since the deregulation of road transport, significant volumes of freight has shifted from other modes to road that has resulted in negative impacts on RFTS. There are regulations and initiatives to combat the negative impacts of road freight. Intermodalism is the most advocated solution towards the sustainability of the transport freight sector.

In terms of M&E frameworks, they are reported to be good as a reflective process for experiential learning and in the handling of complex projects (Crawford & Bryce, 2003; Dobrea, Ciocoiu & Tipa, 2010). Monitoring involves activities of tracking results whilst evaluation consists of assessments performed to evaluate outcomes against objectives.

The subject of sustainability is ancient dating back to the 1600s surfacing through catastrophes of mankind's actions. The concept developed through a desire to restore and preserve the natural environment and its ecosystems. The discussions on best practices and sustainability revealed that efforts have been taken by organisations, businesses and research communities to create sustainable road freight systems.

CHAPTER 4: SYSTEMATIC LITERATURE REVIEW

4.1 Introduction

A systematic literature review (SLR) was used to respond to the second and third research questions of the study, which are *RQ2: What frameworks are there to measure the sustainability of road freight transport systems both globally and in South Africa*? *RQ3: Do the available frameworks measure sustainability holistically?* The chapter takes the reader through how the SLR was conducted for research questions two and three and the findings of the review.

4.1.1 Formulating the search phrase

The researcher began by examining the research questions as a guide to determine the keywords that would be most relevant to use for the search. A table that consisted of Boolean operators and keywords from research question two was populated. The search phrases constructed through Table 4.1 were (Frameworks OR "Monitoring & Evaluation frameworks" OR "Monitoring & Evaluation") AND (sustainability OR sustainable) AND ("road freight transport systems" OR "Freight transport" OR transport) NOT (Passenger).

Table 4.1: Boolean operators and keywords

Boolean operators	AND	AND	AND	NOT
OR	frameworks	Sustainability	"road freight transport systems"	Passenger
OR	"Monitoring & Evaluation frameworks"	Sustainable	"Freight transport"	
OR	"Monitoring & Evaluation"		transport	

A large set of keywords were used to maximise the number of available articles, but the keywords were specific to the research question. For example, “road freight transport” was chosen intentionally to return results that spoke directly to the themes that the research question sought to address.

4.1.2 Source identification and selection

An essential part of the source selection phase is determining which databases will be most suitable to get data for the study and then establishing the boundaries of analysis, also known as the inclusion and exclusion criterion (Paré & Kitsiou, 2017). Figure 4.3 shows the criterion used for this study. Academic databases were chosen for the SLR as they have a recognised level of credibility within the field of research and many records written by researchers and experts in their disciplines.

The researcher searched for databases recommended for logistics and sustainability; logistics and supply chain management research; freight and logistics on Google. Scopus, Science Direct, and Web of Science were databases that came up repeatedly, recommended from the Embry-Riddle Aeronautical University and Northwestern library guides. EBSCO came up as a robust full-text database covering all aspects of sustainability as well as Science Direct from the Federation University A-Z databases on sustainability. The above-mentioned academic databases as well as JSTOR and Sabinet African Journals were recommended by the Stellenbosch University library guide.

4.1.3 Scoping the topic

The topic was scoped to obtain the general size and nature of the available research literature. The search phrase was inserted into the search field of Scopus, Web of Science, Science Direct, EBSCO Host, JSTOR, and Sabinet African Journals**.** The results were returned as presented in Figure 4.1.

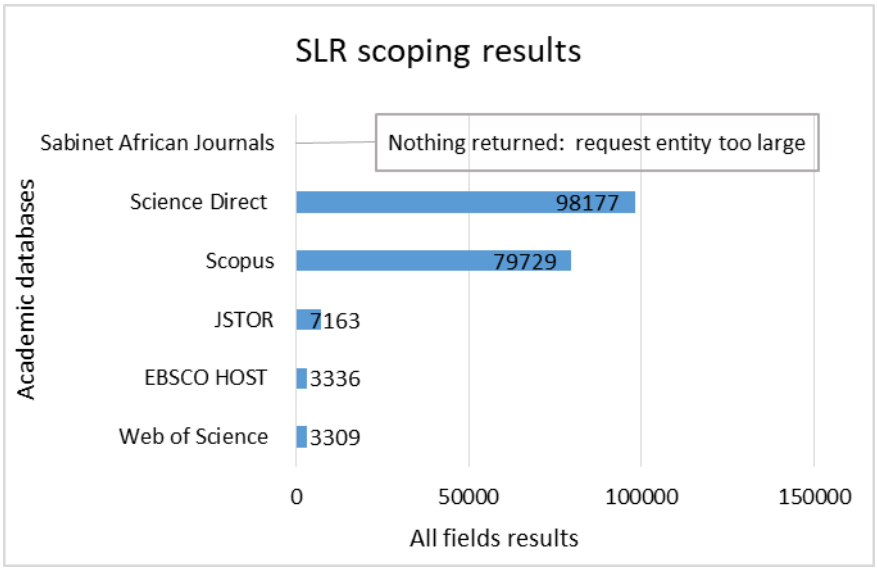


Figure 4.1: Search phrase results under all fields search category

A total of 191 714 results were generated from the academic databases. However, not all the results were relevant to answer the research questions. Although results emerged from the "all fields" category filter, not many articles focused on all or most themes contained in the keywords. Therefore, the search results were narrowed down by opting for the results category "in the title". As a result, only articles that contained the keywords in their title were returned for analysis. This ensured the selection and indexing of only the most relevant results.

4.1.4 Narrowed source results

The same search phrase was reinserted in each academic database. Subsequently, academic database JSTOR and Sabinet African Journals were not included as there were no results returned for the "in the title" search. The results returned are displayed in Figure 4.2. A total of 95 results were returned, of which 55 were article duplicates leaving 40 non-duplicated articles. Six of the 40 articles were not relevant to the research question and three articles lacked full-text access and

as a result, were excluded. Thus, 31 peer-reviewed articles were reviewed and utilised for this study.

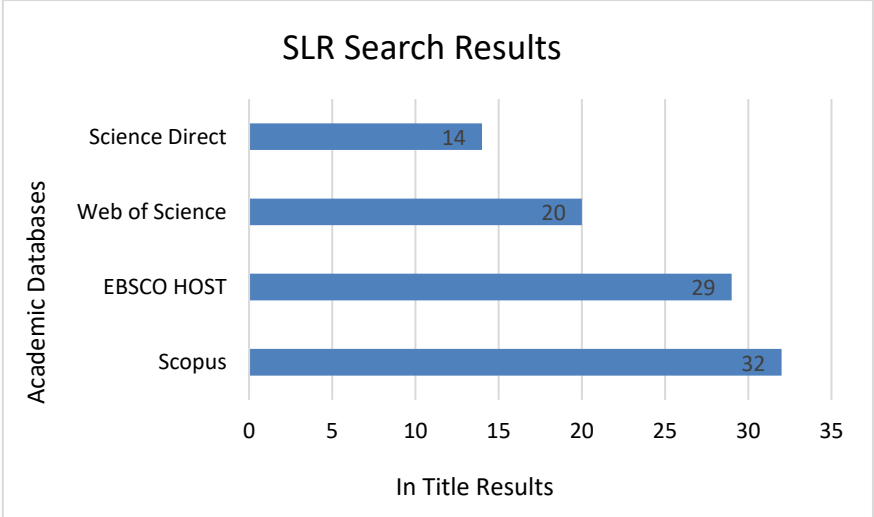


Figure 4.2: Search phrase results under in-title search category

4.1.5 Inclusion criterion

Figure 4.3 represents the inclusion criterion for research question two.

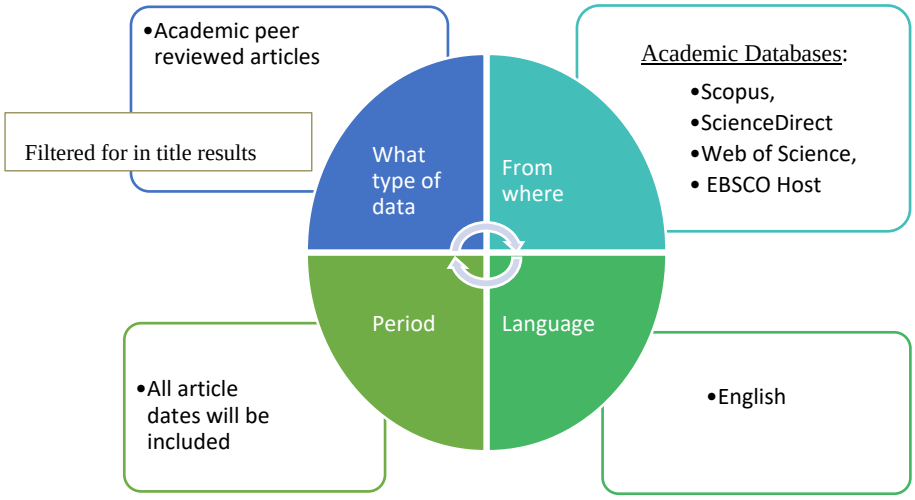


Figure 4.3: Inclusion criterion for research question two

Due to the large number of available articles found from the scoping exercise, grey literature was not consulted. All articles generated by the in-title results were in English. The date did not form an exclusion criterion as the objective of the research question was to find what frameworks there are to measure sustainability for road freight transport systems regardless of when they were developed or documented.

4.1.6 Bibliometrics from Scopus and Web of Science Results

From the four academic databases used to conduct the SLR, only two of the databases provide analysis of the search results, namely Scopus and Web of Science. The same search phrase that was used for the SLR was used to obtain bibliometrics for the documents that were indexed as results for the search phrase generated from Table 4.1 (frameworks OR "Monitoring & Evaluation frameworks" OR "M&E") AND (sustainability OR sustainable) AND ("road freight transport systems" OR "Freight transport" OR transport) NOT (passenger). Four research output analyses were selected that give details on the number of documents published that were used per year, the types of documents published, the top journal sources used in the study's SLR, and lastly, the country in which the documents were published.

Scopus generated the most "in title results" with 32 papers, as shown in Figure 4.2. However, since the bibliometrics available from Scopus' analytics did not include the list of articles specifically used in this study's SLR such as (the articles found on the other databases that were not duplicated or found on Scopus' results, as well as exclude results that formed part of the SLR exclusion criteria) the researcher could not use the bibliometric graphs from Scopus but had to amend the data to match the results specifically used in the study.

Raw data were downloaded from the Scopus database as a Comma-Separated Values (CSV) file from which that data were amended to represent the refined list of articles generated from the study's SLR. Table 4.2 represents how the downloaded data from Scopus was amended to represent the articles/documents used in the study's SLR.

Table 4.2: Logic followed to compile a refined list

Scopus results (32)	
Minus non-relevant articles	-4
Remainder	**28**
Minus no access articles	-2
Remainder	**26**
Plus, unique articles found on the other databases (non-duplicated and not on Scopus)	+8
Scopus remainder plus unique articles =	**34**
(2 of the unique articles were irrelevant and 1 was not accessible)	-3
Total usable articles from SLR search	**31**

The first bibliometric represented in Figure 4.4 is the number of documents published per year.

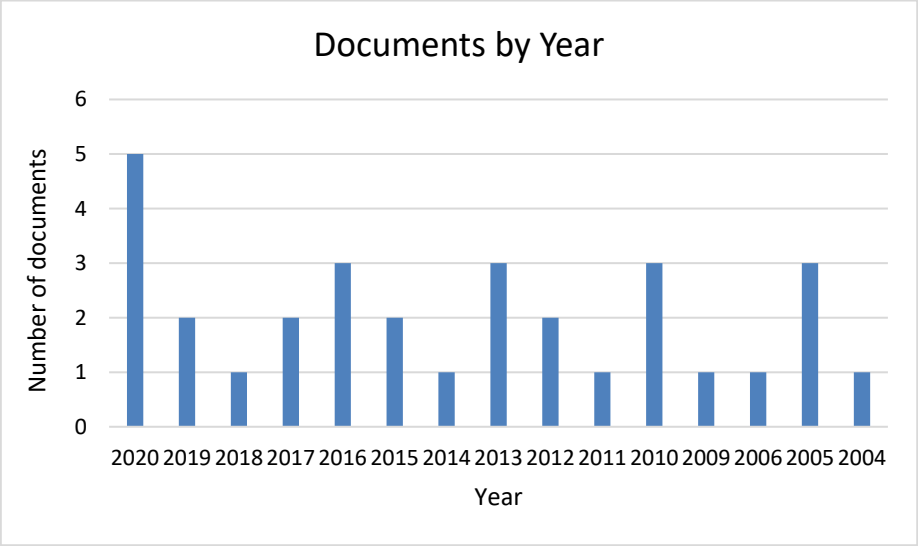


Figure 4.4: Documents by Year

Source: Scopus, 2020

Figure 4.5 plots both the results from the topic search, which includes the terms in the search phrase found in document abstracts, titles, and keywords as well as the title search on one graph. From Figure 4.5, the number of documents found from the title search in each year was under 50 indicating a dramatic decrease from the numbers recorded for the topic results. The search results also show more documents published on the topic in more recent years compared to the previous years.

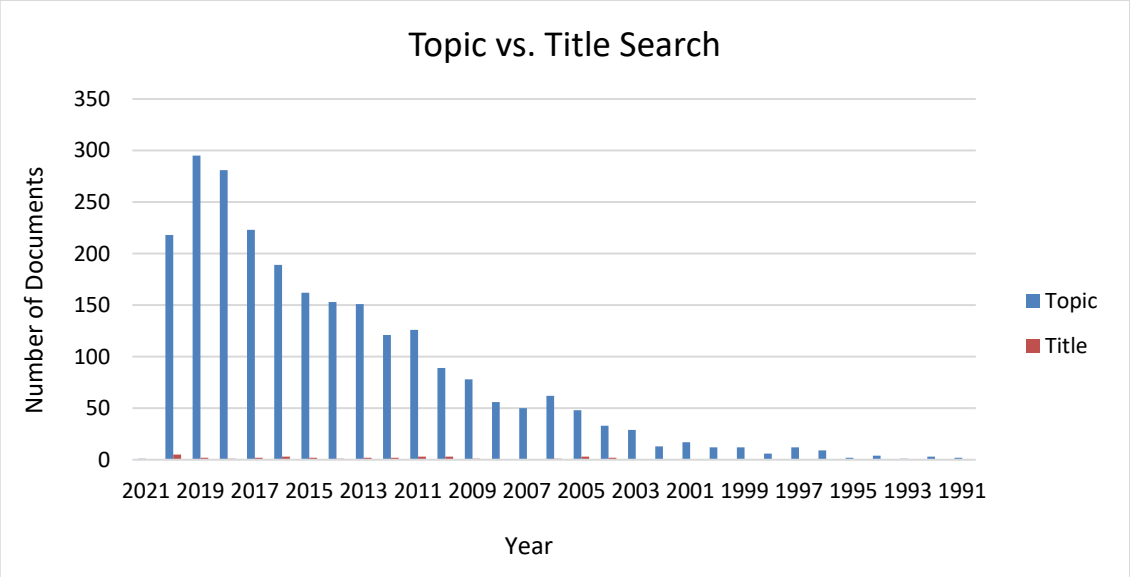


Figure 4.5: Topic search verses Title search

Source: Scopus, 2020

Figure 4.6 displays the top ten journals from which the topic search results were obtained. The journals reflect the subject area/discipline researching the topic. The journal of Social Sciences, Environmental Sciences, and Engineering are the top three journals that contain the documents published generated in Table 4.1's search phrase.

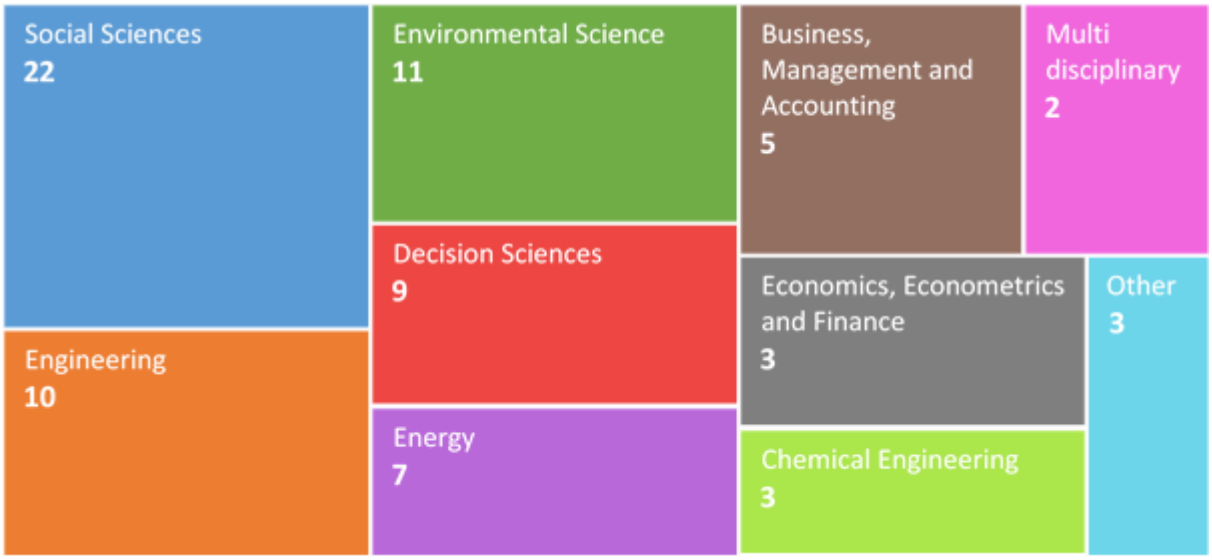


Figure 4.6: Treemap of journal sources

Source: Scopus, 2020

According to the in-title search results displayed in Figure 4.7, the document types are predominately articles. This may be a bias from the databases that were used for the SLR, as 87.1% of the results were articles.

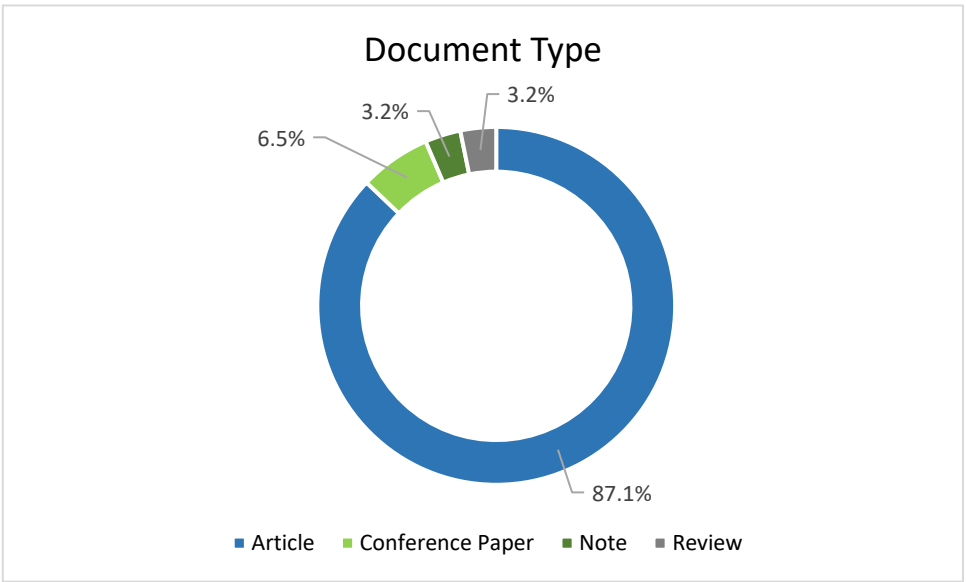


Figure 4.7: Type of documents found through the SLR

Source: Scopus, 2020

The last selected bibliometric was an analysis of the number of publications per country. Figure 4.8 shows the results of the search phrases "in the title" search from the Scopus database, amended to match the study's refined article list. Results show that several countries only had one article published from their region, including South Africa. Australia had the highest number of publications at six, followed by the United States. Germany, France, and China had the same number of papers (two) on this subject.

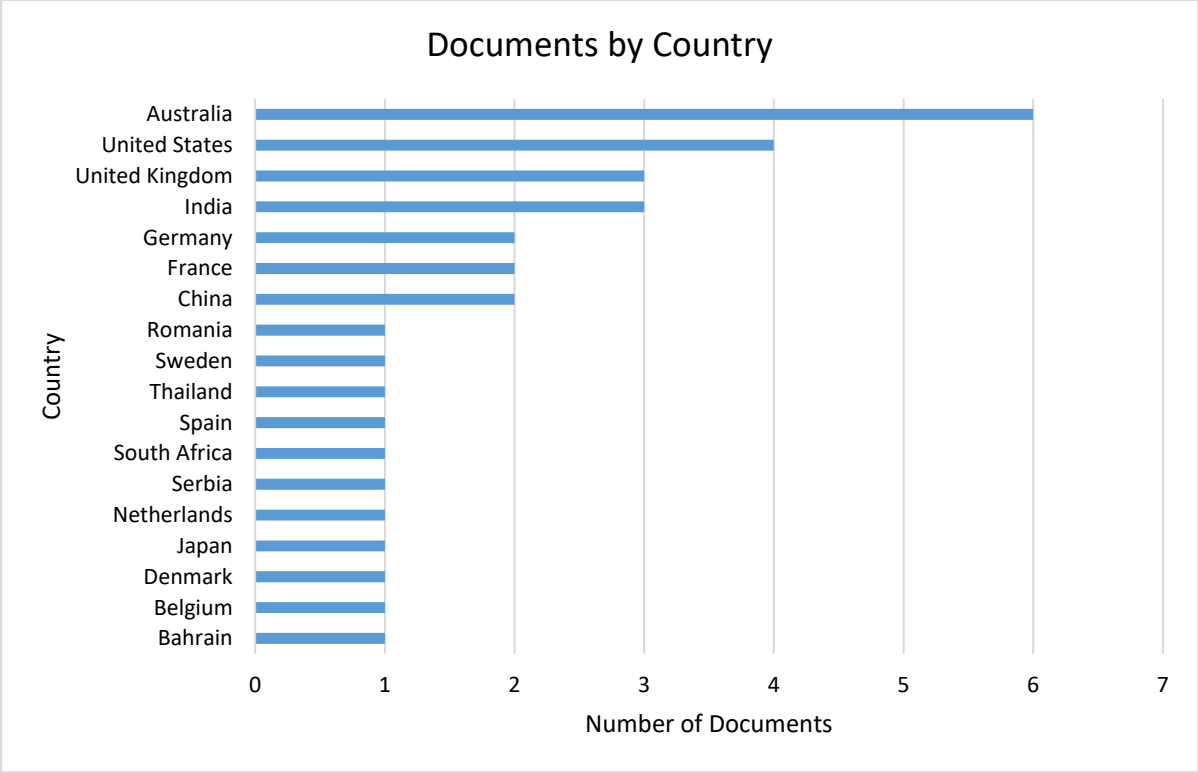


Figure 4.8: Documents by country

Source: Scopus, 2020

4.1.7 Overview of findings

The transport system has been measured and evaluated by many models and frameworks. The purpose that leads to the development of a sustainability framework for road freight transport is not consistent but varies and is unique to specific cases. Reviewed models and frameworks tend to focus on economic and cost indicators, while others integrate sustainability factors into their frameworks for transport-related undertakings. Wang (2014) states that there is no standard

framework to measure the sustainability of transport systems, as the definition of sustainability and purpose of developing a framework differ amongst authors.

Numerous frameworks and models in literature measure sustainability in transport systems. The frameworks identified through this study's SLR had specific objectives, including screening urban transport in developing countries (Jones, Tefe & Appiah-Opoku, 2013), conducting strategic and sustainable transport appraisals (Wang, 2014; Barfod & Salling, 2015; Yazdani, Pamucar, Chatterjee & Chakraborty, 2019) and the development of sustainable indicators (Nathan & Reddy, 2013). Some frameworks were developed from the perception of existing frameworks' limitations and shortcomings, resulting in the adaptation of existing frameworks and the combination of multiple models into a single framework.

The frameworks found from the SLR can be classified to predominately fall under the following three areas: firstly, those based on decision-making methods, secondly, those based on indicator-based frameworks, and thirdly, those based on conceptual frameworks.

4.1.7.1 Decision-making methods

The articles from the search results modelled frameworks based on decision-making methods such as; Cost-Benefit Analysis (CBA), Multi-Criteria Decision Analysis (MCDA), Feasibility Risk Assessment (FRA) (Barfod & Salling, 2015), Analytical Hierarchy Process (AHP), Social Cost-Benefit Analysis (SCBA), Multi Actor Multi-Criteria Analysis (MAMCA), Cost-Effectiveness Analysis (CEA) and expert consulting (Yazdami & Pamucar, 2019). The frameworks that incorporated decision making methods lead to the ranking of alternatives to aid in decision making for sustainable transport systems. There are many decision-making methods available for the evaluation and appraisal of transport projects (Macharis & Ampe, 2008).

Cost-Benefit Analysis (CBA)

Cost benefit analysis is used for the systematic quantification and evaluation of numerous costs and benefits resulting from a project (Banister & Berechman, 2000; Barfod & Salling, 2015). This decision-making method is used to support decision-makers with infrastructure plans amongst others to translate the estimated costs and benefits in monetary terms for the different alternatives to be evaluated (Beukers, Bertolini & Te Brömmelstroet, 2012).

Although CBA is a useful tool for transport appraisals, CBA is limited in the assessment of multiple and incompatible variables. For example, decisions with different objectives, criteria, or dimensions to be evaluated that are usually inherently difficult to quantify like the social and environmental dimensions of sustainability (Mackie & Preston, 1998; Barfod, Salling & Leleur, 2011; Beukers *et al*. 2012). Sustainability in the area of transport infrastructure projects has a rapidly growing interest. As a result, Van Exel, Rienstra, Gommers, Pearman and Tsamboulas, (2002), Wright, Nelson, Cooper and Murphy (2009), as well as Barfod, (2012), advocate for the review of traditional decision-making processes of CBA beyond its solely economic considerations. Decision-making frameworks that comprise multi-disciplinary and multi-criteria approaches can access decision problems, which would include criteria such as the triple bottom line (Banister, 2008).

Multi-criteria decision analysis (MCDA)

Multi-criteria decision analysis (MCDA) and multi-criteria decision making (MCDM) are used interchangeably by authors. They are generic terms used for various methods that assist in making decisions where several conflicting criteria are present (Ho, 2008). Multi-criteria decision analysis is applied to a wide range of decision-making problems. The procedures include algorithms, preference ranking, and paradigms. Literature represents this method in various forms, as models, assessment methodologies, and evaluation theories (Fishburn, 1978; Zavadskas, Skibniewski, & Antucheviciene, 2014; Zavadskas, Kaklauskas & Vilutiene, 2009).

The MCDA methodology has been used in transport planning to address the issue of assessing criteria impacts that are difficult to quantify or give a monetary value (Keeney & Raiffa, 1993; Belton & Stewart, 2002; Sayers *et al.* 2003; Vreeker *et al.* 2002; Janic, 2003; Tsamboulas & Mikroudis, 2006; Edwards *et al.* 2007; Tsamboulas, 2007; Barfod, 2012). Due to difficulties in the assessment of certain criteria or project objectives with some decision-making methods, several authors (Vertonghen, 1992; Bekefi, Kiss &Tanczos, 2003) recommend that both MCDA and CBA be used in conjunction, as together they can provide complementary insights.

Feasibility Risk Assessment (FRA)

Feasibility risk assessment is used to assess the risk where the investment to finance a project and the demand could be miscalculated, resulting in economic infeasibility. FRA examines the project

alternatives and uses the results as inputs of the criteria for MCDA (Barfod & Salling 2015). The paper reviewed by Salling and Leleur (2012) examined uncertainties as a part of quantitative risk assessment of transport-related impacts, such as construction costs and travel associated benefits. The paper makes use of nine exploratory scenarios, which are used to represent reflections of uncertainty over long-term transport planning and are expected to shed light on the feasibility of the investment appraisal.

Analytical Hierarchy Process (AHP)

The AHP method takes biased human judgments and presents them in the form of a linear equation (Olson, 2008). While results from the AHP method may in some cases reflect consistency in the decision-makers' preferences and even produce accurate rankings of alternatives in other cases; Dyer (1990) argued that the results cannot be regarded as deductive. Barzilai, Cook, and Golany, (1987) proposed for the geometric mean be used to rank alternatives as opposed to the commonly used eigenvectors to identify relative importance. AHP continues to be a preferred multi-criteria decision support system despite the criticism it has received from some authors (Belton & Gear 1983; Dyer 1990). The flaws in the implementation of this method are argued by Harker and Vargas (1987) to be arbitrary and as a result of the misunderstanding of the method's theoretical foundations.

Social Cost-Benefit Analysis (SCBA)

The use of SCBA has been advocated by the public sector in some countries for large transport infrastructural investments. The method is formed from the Welfare Theory principle, around the conventional criteria of monetary gains. The conventional criteria view is adapting to include the market effects as well as non-market effects of decisions.

Both the internal rate of return and the net present value of the project is calculated with the discount rate. In reality, there are some inconsistencies with theory and practice. In theory, all applicable effects are considered, but in practice, some effects remain uncertain during the analysis (Ferreira & Lake, 2002). Due to this, SCBA can give an indication of the efficiency of a measure or alternative, but the method is unable to realise the true extent of externalities or intangible benefits, and therefore, cannot be solely relied upon to determine whether a project is socially justifiable, but can only paint a picture (Macharis, De Witte, and Ampe, 2009).

Multi Actor Multi-Criteria Analysis (MAMCA)

Like the other decision-making methods, MAMCA evaluates alternatives. Although, this particular method considers stakeholder opinions in the initial stages of the decision-making process. Ampe *et al* (2009) outline seven steps on how to conduct MAMCA.

Step 1 is to define the problem and identify alternatives. Step 2 is to determine the criteria that will be used. The involvement of stakeholders very early in the process is what sets the MAMCA approach apart from MCDA. The criteria reflect the objectives of the stakeholders and in the third step, weights are assigned to the criteria that act as a means to rank the importance of the objectives according to the preference of the stakeholders. In step 4, indicators, or ordinal scores, for example, Likert scales are assembled to obtain quantitative measures or scores for the different alternatives. Steps 1-4 are a fundamental part of the MAMCA process, which leads to the overall analysis. Step 5 involves the totalling of each alternative's score to the objectives of the stakeholders through an evaluation matrix. Step 6 reveals the strengths and weaknesses of each proposed alternative. Finally, step 7 involves implementation. Figure 4.9 illustrates the steps of the MAMCA process as explained above.

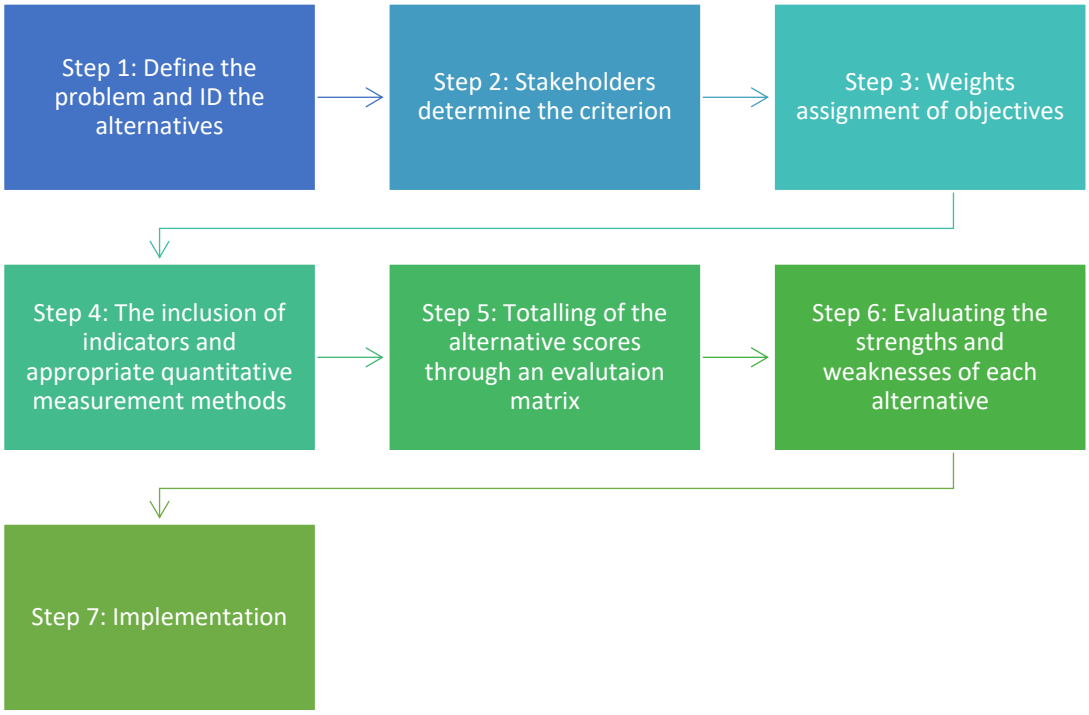


Figure 4.9: MAMCA process flow

Source: Adapted from Macharis, De Witte, and Ampe (2009)

4.1.7.2 Indicator based frameworks

Frameworks for selecting indicators to measure sustainability were prevalent among the literature reviewed. Indicator based frameworks were found in the studies of Pei, Amekudzi, Meyer, Barrella, and Ross (2010); Toth-Szabo and Várhelyi (2012) and Nathan and Reddy (2013). They focused on identifying, selecting, developing, monitoring, measuring performance, and reviewing prominent sustainable transport indicators.

4.1.7.3 Conceptual frameworks

Conceptual frameworks can be found in Mattioli (2016). Shields and Rangarajan (2013) describe conceptual frameworks as an analytical tool to organise ideas to provide guidance regarding interrelated objects or transactions between ideas/variables. Many articles that resulted from the SLR used graphical illustrations as a means to explain and display the inter-related concepts of their frameworks. The conceptual frameworks varied and were applied in different contexts.

4.2 Holistic Sustainability

This study's third research question sought to investigate whether the road freight transport frameworks reviewed in the SLR assess sustainability holistically. The criteria used to gauge holistic sustainability was the Triple Bottom Line (TBL) - (economic, environmental, and social dimensions). These are conventional pillars of sustainability dimensions that formed the focus of this study. Although the TBL forms the scope of which the frameworks assessed in this study are measured, this study notes that there is a fourth pillar of sustainability mentioned in the literature. This fourth pillar is briefly analysed in section 4.2.1. Section 4.2.2 describes the method used in the SLR conducted for the third research question and then section 4.2.3 details the literature found, concluding whether the available SLR frameworks assess sustainability for the road freight transport sector holistically.

4.2.1 Views beyond the TBL

Ideas around holistic sustainability and achieving it are grouped non-sequentially in Figure 4.10 and further narrated below.

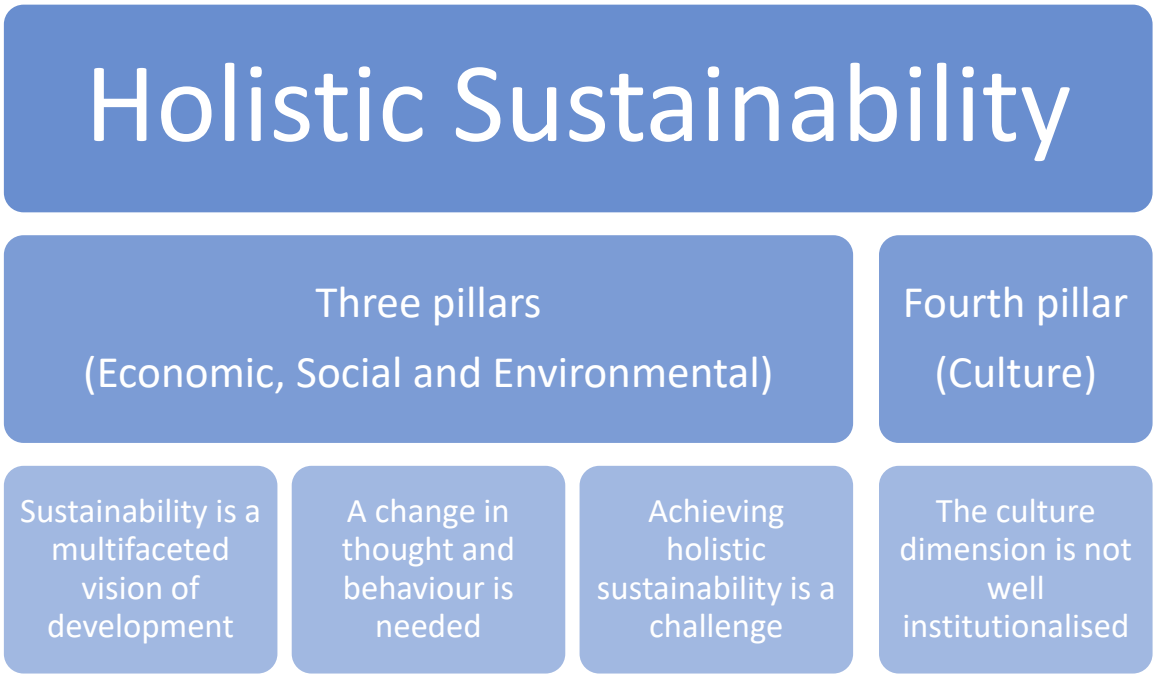


Figure 4.10: Grouping of section 3.2.1 ideas

Source: Created by author, 2020

Holistic sustainability is described to be a multifaceted vision for development that sets out to sustain life. In this vein, Raskin (1993) believes the improvement of the human condition is a primary goal of sustainable development. However, Raskin (1993) further argues that the growth of any economic, educational, political, and cultural strategy that deters nature beyond its point of self-regeneration is absurd and irresponsible.

While sustainable development is conventionally known to encompass three pillars of sustainability, Hawkes (2001); Throsby (2008); Chiu (2004); Nurse (2006) and Birkeland (2008) considered and explored the aspect of culture as the fourth pillar of sustainability. In the study by Soini and Birkeland (2014), the discourse of cultural sustainability is investigated. In studies, cultural sustainability is predominately taken into account in the field of policy. It is often mentioned as an aspect linked to the social dimension of sustainability or at times a dimension of its own.

The introduction of culture in sustainable development in the international, national, regional, and local arenas has come through policy initiatives (Chiu, 2004; Throsby, 2008). The interrelationship between development and culture has appeared in several United Nations Educational Scientific and Cultural Organization (UNESCO) reports and conventions such as the UNESCO Decade of Culture and Development (from 1988 to 1997), as well as the 'Convention for the Safeguarding of the Intangible Heritage' (UNESCO, 2001) and the Convention on the 'Protection and Promotion of Diversity of Cultural Expressions' (UNESCO, 2005).

Although the concept of culture is contained and discussed by the UNESCO reports and conventions, Soini and Birkeland (2014) argue that culture and sustainable development have not been explored extensively in the mentioned documents. Culture can be argued to have not yet been institutionalised or systematically included as an aspect of sustainable development, as compared to social, economic, and ecological sustainability; in practice, through policies, or in assessments (Chiu, 2004 and Throsby, 2008).

Raskin (1993) continues to state that addressing sustainability holistically is a challenge, as multiple qualitative aspects of life and development stand in a causal relationship. For example, matters such as poverty, wealth, political scarcity, underdevelopment, and environmental preservation. Due to the qualitative nature of this development, it is impractical for the current structures of industrial society to remain unchanged whilst seeking to obtain holistic sustainable development. Achieving the vision of holistic sustainability requires a reconstruction of the central business aim on capital accumulation as a priority and the present unsustainable industrial principles, which lead to an unsustainable civilisation. It is fundamental to strike a balance between the different pillars of sustainability and their synchronous implementation.

4.2.2 Research question three SLR methodology

This section outlines the method used to conduct an SLR to answer Research Question Three (RQ3): *Do the currently available frameworks assess sustainability holistically for road freight transport systems?*

An SLR was the preferred method chosen to answer this research question due to its objective approach in selecting documents and its replicable nature in obtaining scientific articles and documents. The first step followed for this research question was translating the research question into a search phrase that would return relevant results containing information that would assist in

answering the question. The aim of the research question was used to plot keywords in a table with Boolean operators as shown in Table 4.3.

Table 4.3: Boolean operators and keywords

Boolean operators	AND	AND	AND	NOT
OR	frameworks	Sustainability	"road freight transport systems"	Passenger
OR	"Monitoring & Evaluation frameworks"	Sustainable	"road freight transport"	

The search phrase derived from Table was (Frameworks OR "Monitoring and Evaluation frameworks") AND (Sustainability OR sustainable) AND ("road freight transport systems" OR "road freight transport") AND NOT (Passenger). This search phrase was used in the Scopus database and returned 17 results filtered by the abstract, title, and keywords.

A second search was conducted with the same search phrase but including the keyword South Africa OR SA. (Frameworks OR "Monitoring and Evaluation frameworks") AND (Sustainability OR sustainable) AND ("road freight transport systems" OR "road freight transport") AND ("South Africa" OR SA) AND NOT (Passenger). This search phrase was also inserted into the Scopus database and only returned one result from the abstract, title, and keywords filter category. The result was an article by Havenga (2011) 'Framework for rail freight transport revival in South Africa'.

The researcher then expanded the search by reinserting the search phrase that included South Africa and filtered by all fields to gauge whether more results would be returned. This search resulted in 41 documents returned. The results were reviewed by reading the titles, abstracts, and keywords. It was found that these results were not written from a South African perspective and addressed the research problem in respect of another country. The documents that were reviewed

did not include or mention South Africa in their abstract, title, or keywords and lastly, the topics were not related to the keywords for RQ3.

As an example of the topics indexed from the all fields search; Sachs, McArthur, Schmidt-Traub, Kruk, Bahadur, Faye, and McCord, (2004) wrote a review on 'Ending Africa's poverty trap'. Mangiaracina, Perego, Salvadori, and Tumino, (2017) investigated intelligent transport systems, using technology to inform traffic and weather conditions. Riddell, van Delden, Maier, and Zecchin, (2020) looked at 'Tomorrow's disasters–Embedding foresight principles into disaster risk assessment and treatment' and, therefore, due to the lack of topic relevance or relation to South Africa, the results from all fields' exploration were concluded as irrelevant.

Four questions in Figure 4.11 were asked whilst reviewing the relevant search results obtained from the first search conducted for RQ3 with 17 document results as summarised in Table 4.4.

Figure 4.11: Review questions for RQ3

Source: Author, 2020

Only one of the articles obtained from the search results was excluded as the abstract could not provide sufficient information to answer the four review questions in Figure 4.11 and no full text of the article/document was available to review and obtain content that would assist in answering the review questions.

Table 4.4: Summary of RQ3 search results and their sustainability focus

Article title	Author	Date	Social	Environmental	Economic	Holistic	Focus
Decision support system applied to combined freight transport	Rigo and Ndiaye	2008		X	X	NO	Integrated decision aiding tool for road freight transport alternatives
Framework for rail freight transport revival in South Africa	Havenga and Pienaar	2011			X	NO	Rail and road modal shift (road (trucks) to rail migration)
Improving the sustainability of road freight transport by relaxing truck size and weight restrictions.	McKinnon	2011		X	X	NO	Road freight transport (LHV trucks)
Sustainable mobility and goods distribution system. The case study of the central area of Thessaloniki.	Basbas and Bouhouras	2012	NO ACCESS				

Article title	Author	Date	Social	Environmental	Economic	Holistic	Focus
Motorways of the sea policy in Europe.	Aperte and Baird	2013			X	NO	Shift from Road to Sea
A security plan procedure for Heavy Goods Vehicles parking areas: An application to the Lazio Region (Italy).	Carrese, Mantovani and Nigro	2014			X	NO	Heavy Good Vehicles (HGV)
The use of ICT in road freight transport for CO2 reduction–an exploratory study of UK's grocery retail industry.	Wang, Rodrigues and Evans	2015		X		NO	Use of information and communication technologies (ICT) in Road freight transport
The longer and heavier vehicle debate: A review of empirical evidence from Germany.	Rodrigues, Piecyk, Mason and Boenders	2015		X	X	NO	Longer Heavier Vehicles (LHV)

Article title	Author	Date	Social	Environmental	Economic	Holistic	Focus
Sustainability assessment of alternative fuels for freight transport: methodological approach and case study for liquefied natural gas.	Osorio-Tejada, Llera-Sastresa and Scarpellini	2016	X	X	X	YES	Road freight transport impact assessment framework
Policy-oriented emission factors for road freight transport.	Dente and Tavasszy	2018		X		NO	Road freight transport
A novel approach for assessing sustainable city logistics.	Nathanail, Adamos and Gogas	2017	X	X	X	YES	Urban Freight Transport (UFT) life cycle analysis (LCA)
Environmental sustainability in third-party logistics service providers: A systematic literature review from 2000–2016.	Evangelista, Santoro and Thomas	2018		X		NO	Road freight transport third-party logistics service providers (3PLs)

Article title	Author	Date	Social	Environmental	Economic	Holistic	Focus
Energy efficiency in logistics: an interactive approach to capacity utilisation.	Wehner	2018		X		NO	Road freight transport (last mile and reserve logistics)
Improving the sustainability of road freight transport by relaxing truck size and weight restrictions.	McKinnon	2014		X	X	NO	Road freight transport (LHV trucks)
Prospects for electrification of road freight.	Nicolaides, Cebon and Miles	2017		X		NO	Road freight transport electrification framework
Decomposing growth in Norwegian seaport container throughput and associated air pollution.	Rødseth, Schøyen and Wangsness	2020	X	X		NO	Shifting road freight to maritime

4.2.3 Frameworks reviewed in SLR

The documents in Table 4.4 were reviewed to perceive the knowledge and frameworks available that address sustainability in the road freight transport sector. The four review questions in Figure 4.11 were asked to assist in analysing the results to determine if the frameworks in the literature assess sustainability holistically for road freight transport. The results obtained through the SLR for RQ3 returned some documents that investigated sustainability within the road freight transport sector but did not necessarily provide a framework for assessment.

A framework to assess sustainability was a key aspect of the research question and due to the lack thereof in some documents summarized in Table 4.4, the researcher saw it fit to include findings of the results from RQ2 that incorporated frameworks for road transport systems to be able to determine whether available frameworks from both searches assess sustainability holistically for road freight transport.

The reviewed documents from the SLRs assessed, developed, implemented, and analysed factors within the road transport sector relating to sustainability. Some articles presented a unique framework that had special applications for different contexts, and with different outcomes. The articles reviewed address an aspect of the TBL in the sense that they spoke to environmental, social, and economic issues. Nathan and Reddy (2013) compiled a framework that consists of 54 indicators, which are classified into three dimensions referred to in the article as Ecological Acceptability; Social Wellbeing; and Economic Efficiency. The Jones, Tefe, and Appiah-Opoku (2013) study screened urban transport projects in developing countries using TBL sub-criteria goals in their framework. These articles were holistic in addressing sustainability with the inclusion of social, economic, and environmental dimensions incorporated in their frameworks.

Review question four from Figure sought to identify the gaps in literature relating to RQ3. The first evident gap was that many of the results in Table 4.4 did not address sustainability holistically like (Havenga, & Pienaar, 2011; Oberhofer & Fürst, 2012; Aperte, & Baird, 2013; Carrese, Mantovani & Nigro, 2014; McKinnon, 2014; Rodrigues, Piecyk, Mason & Boenders, 2015; Wang, Rodrigues & Evans, 2015). Figure 4.12 shows how many documents from RQ3's SLR search encompassed sustainability holistically; 87.5% of the documents did not address all dimensions of the TBL.

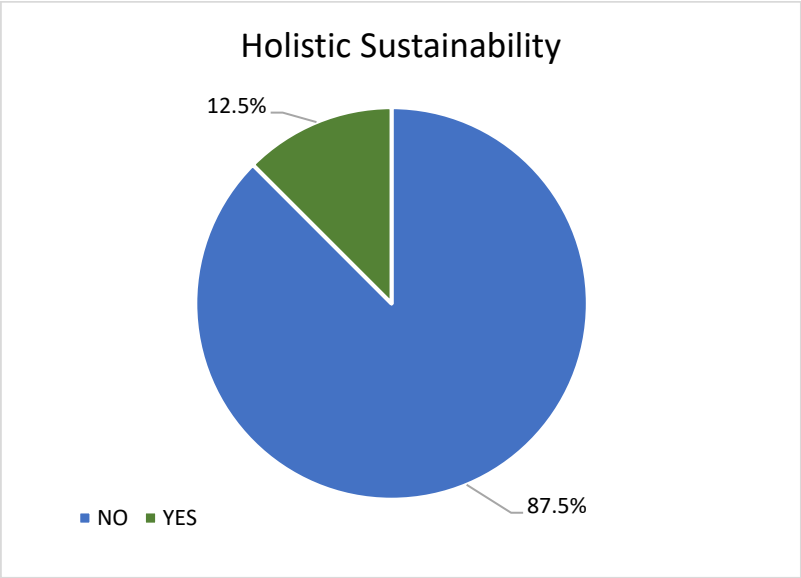


Figure 4.12: The percentage of documents in Table 3.4 that address sustainability holistically

Source: Author, 2020

The extent to which the TBL is addressed in each article varies. For instance, Mattioli (2016) critically analysed the role of transport as it related to human needs satisfaction, focusing on the social dimension but still mentioned the other two dimensions of sustainability. Whereas Neagu, (2018) specifically discusses the economic and social benefits associated with his fog computing framework for smart cities. In Neague's (2018) study, the environmental benefits are not explicitly mentioned, but some implications benefit the environment even if indirectly. These benefits included reduced resource consumption and alleviating traffic congestion. Other authors such as Kane and Whitehead (2017) and Shen & Newman (2015) do not explicitly focus on all the dimensions of the TBL, but their frameworks and proposals have ripple effects that benefit each sustainability dimension.

Other studies did not provide frameworks (Oberhofer & Fürst, 2012; Aperte & Baird, 2013), whilst others had a unique focus for example vehicle electrification (Nicolaides, Cebon & Miles, 2017), parking areas for HGVs (Carrese, Mantovani & Nigro, 2014), and ICT support and solutions (Wang, Rodrigues & Evans, 2015; Evangelista, Santoro & Thomas, 2018) within the road freight transport sector, forming the second and third gap identified.

Based on the frameworks reviewed in this study's two SLRs, one can conclude that several frameworks assess sustainability holistically within the transport sector, but as one narrows the

search specifically for road freight transport as done in the SLR for RQ3, the results start to decrease. The results are even further reduced as one searches for frameworks including South Africa as a keyword. Thus, it can be concluded from the two SLR's that a well-balanced standardised framework specifically developed to assess sustainability in road transport systems in South Africa is needed.

4.3 Conclusion

The SLR conducted for research questions two and three revealed various types of frameworks for assessing road freight transport systems (RFTS). Decision-making methods were the most frequently presented methods found from the SLR among indicator-based frameworks, conceptual works, and others. Investigating whether there were sustainability frameworks to assess RFTS in South Africa, only one article mentioned or related to South Africa but was still considered irrelevant as it focused on rail freight. The search results from the holistic sustainability search resulted in 12.5% of the documents reviewed addressing sustainability holistically. These findings corroborate with the discussions on sustainability in chapter three that ecological matters formed the origins of sustainability and its dimension has dominated the topic.

CHAPTER 5: FRAMEWORK DEVELOPMENT

5.1 Introduction

The main purpose of this study was to develop an M&E sustainability assessment framework for road freight transport in South Africa. Toth-Szabo and Varhelyi (2012) state that measuring sustainability must be done from the foundation of a definition and vision of sustainability for regions or areas being measured. Section 5.1.1, therefore, starts with the operational definition of this study as well as South Africa's vision of sustainability for the transport sector. These form the foundation on which this study's framework is developed. Section 5.1.2 briefly outlines the challenges faced in South Africa's road freight transport sector to understand the plight and context in which this study's framework is developed. This helps to ensure that the framework addresses the identified challenges. Section 5.1.3 contains an adapted road freight transport diagram that seeks to outline and provide an overview of the linkages and relationships of different components of the road freight transport system and how they affect the sustainability of the system. The diagram together with insights from section 5.1.2 highlights areas in the system that need to be measured to be able to achieve sustainability for road freight transport systems (RFTS). Section 5.1.4 covers the framework developed for the study through a culmination of the research questions one to three. Lastly, a summary of the expert review of the framework is found in section 5.2 and the chapter is concluded in section 5.3.

The first step in developing the M&E sustainability assessment framework for road freight transport in South Africa is to analyse definitions for operational transport sustainability and the country's vision for sustainability in the transport sector.

5.1.1 The study's operational definition of transport sustainability and South Africa's vision for sustainability in the transport sector

Latham's (2004) article on goal-setting theory emphasizes the importance of clear goal definitions and how that improves performance. It improves performance as clearly defined goals give direction and enable one to measure their performance. Defining what sustainability in transport is assists in laying down the requirements needed to obtain the goal. If the reality does not resemble the definition or vision of sustainability in the transport sector, then sustainability in the transport sector would not be met/achieved. Therefore, defining sustainability in the transport sector is

important to know the standards required and to be able to measure performance. This study's operational definition of sustainability in the transport sector is as follows:

A sustainable transport system is one that is ***accessible spatially*** *allowing* ***mobility needs*** *to be met* ***safely and affordably*** *with* ***social cost considerations*** *(private cost and cost of externalities). The system* ***operates efficiently with infrastructure*** *that is an* ***asset to communities****, offering a* ***modal choice*** *that is* ***competitive*** *and* ***boosts socio-economic development****; ensuring* ***future generations are not compromised*** *to cater to the needs of current societies. Sustainable transport* ***limits the emission*** *of air pollution, noise pollution, and GHG's.* ***It minimises the use of land****,* ***consumption of non-renewable*** *and renewable resources as well as material resources needed to support the transport system. It* ***minimises waste****, reuses, and recycles its components. It decreases its impact on environments,* ***protecting ecosystems,*** *and the global climate. Sustainable transport systems* ***support the economic, social, and environmental pillars*** *and are designed to* ***involve stakeholders****.*

The definition was constructed from multiple definitions found in the literature on transport sustainability world-wide and encompasses all the themes brought forward by authors in Tab. A transport system that meets the description of this operational definition would be sustainable. The South African government's vision of sustainable transport is not dissimilar to the operational definition of this study. Similarities and differences are expressed in Figure 5.1.

According to the National Transport Policy White Paper of the South African Department of Transport (1996), the envisioned transport system will:

"Provide ***safe, reliable, effective, efficient,*** *and* ***fully integrated transport operations*** *and* ***infrastructure,*** *which will best* ***meet the needs of freight and passenger customers*** *at* ***improving levels of service and cost*** *in a fashion which* ***supports government strategie****s for* ***economic*** *and* ***social development*** *whilst being* ***environmentally*** *and* ***economically sustainable****".*

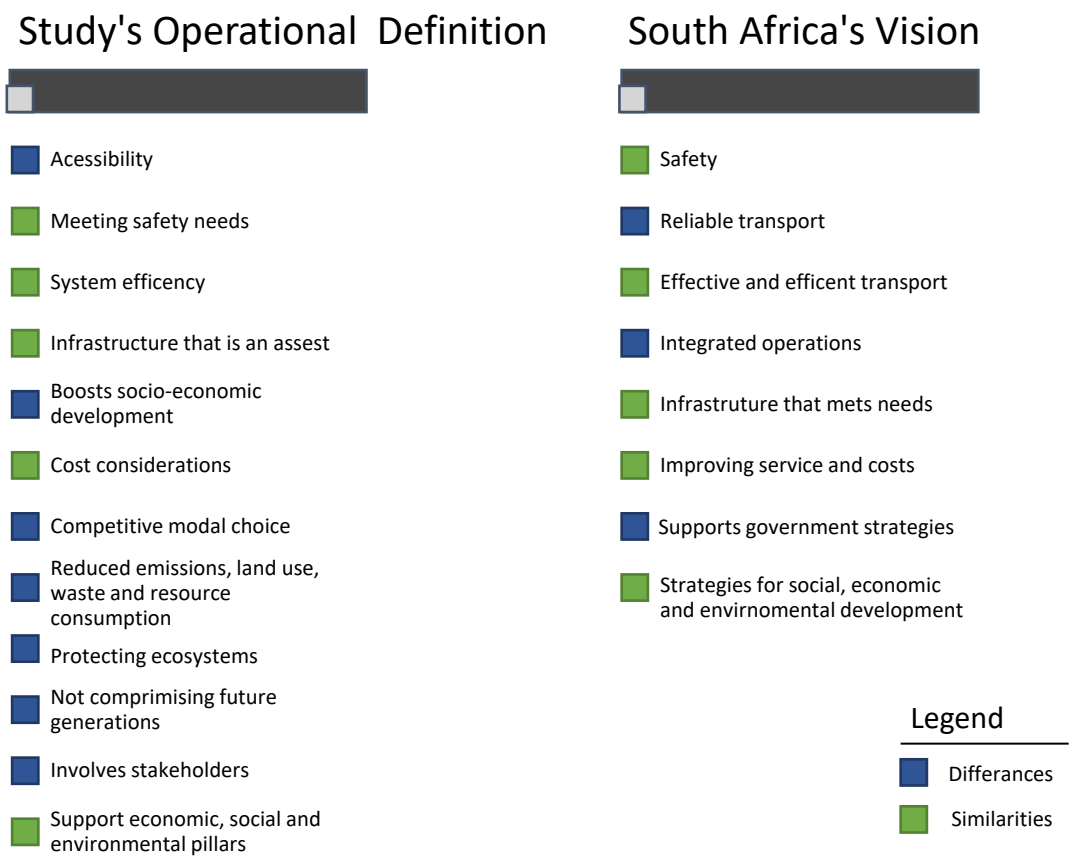


Figure 5.1: Key themes from the study's operational definition and South Africa's vision for sustainability and their differences and similarities

Source: Created by author, 2020

The South African government is a signatory to many international conventions and groups concerning transport sustainability. For instance, the Chicago Convention for Aviation, the International Road Traffic and Crash Database Group (IRTAD), the United Nations Framework Convention on Climate Change (UNFCCC), and the Paris Agreement, which encourages a move towards fossil fuel divestment to name a few commitments and agreements the country has participated in towards creating a sustainable transport system in South Africa (DoT, 2017; DoT, 2018).

The country's participation solidifies its commitment to providing a transport system that is world-renowned and sustainable. This pursuit is in line with the highest legislation of the country, Constitution Act 108 of 1996, which pronounces in Chapter 2, Section 24:

"Everyone has the right to an ***environment that is not harmful to their health or well-being****;* ***and to have the environment protected for the benefit of present and future generations****, through reasonable legislative and other* ***measures that prevent pollution and ecological degradation, promote conservation, and secure ecologically sustainable development*** *and* ***use of natural resources****, while* ***promoting*** *justifiable* ***economic and social development****."*

The Government's Green Transport Strategy (2018-2050) focuses on achieving the envisioned transport system. It is underlined by sustainable development principles. The strategy is intended to support and promote green economic growth targets, green mobility, and safeguarding the environment. The transformations that are required in the transport sector will not be easily achieved, but are necessary as they would provide improved public and environmental health, less congested roads, and a more efficient system.

The benefits counteract negative externalities produced by the system and afford citizens and transport users their rights articulated in Chapter 2, section 24 of the constitution. The developed framework in this study is guided by the vision of the South African government for the transport system and this study's operational definition forms the foundation to construct the M&E sustainability assessment framework for the study.

5.1.2 Road freight transport challenges in South Africa

Substantial volumes of freight moved from rail to road from 1988 as a result of the deregulation of road freight in South Africa. Since then, road freight traffic has increased and continues to increase with the lack of competitiveness from rail and other transport modes (DoT, 2018). Heavy Goods Vehicles (HGV) make up 34% of the traffic on the N3 (DoT, 2018), a national road that connects South Africa's largest city in Gauteng to the closest port in South Africa which is situated in Durban. The increased traffic from HGVs has also come with many negative externalities, such as rapidly deteriorating road infrastructure, high crash levels, congestion, and increased pollutant emissions (DoT, 2017).

Road transport is the key contributor to the total transport-related $C0_2$ emissions in South Africa. Figure 5.2 shows that the road sub-sector accounts for 91.2% of the 10.8% total Greenhouse Gases (GHG) emitted by the transport sector and rail transport emitting only 1.07% (STATS SA, 2011; DoT, 2017). Managing the cause and effects of global warming is a global priority, and due to the high negative externalities that road transport contributes, road transport is the focus of the

government's (2018-2050) Green Transport strategy. As road transport contributes to the greatest negative externalities in the transport sector, it thus offers the greatest reduction opportunities.

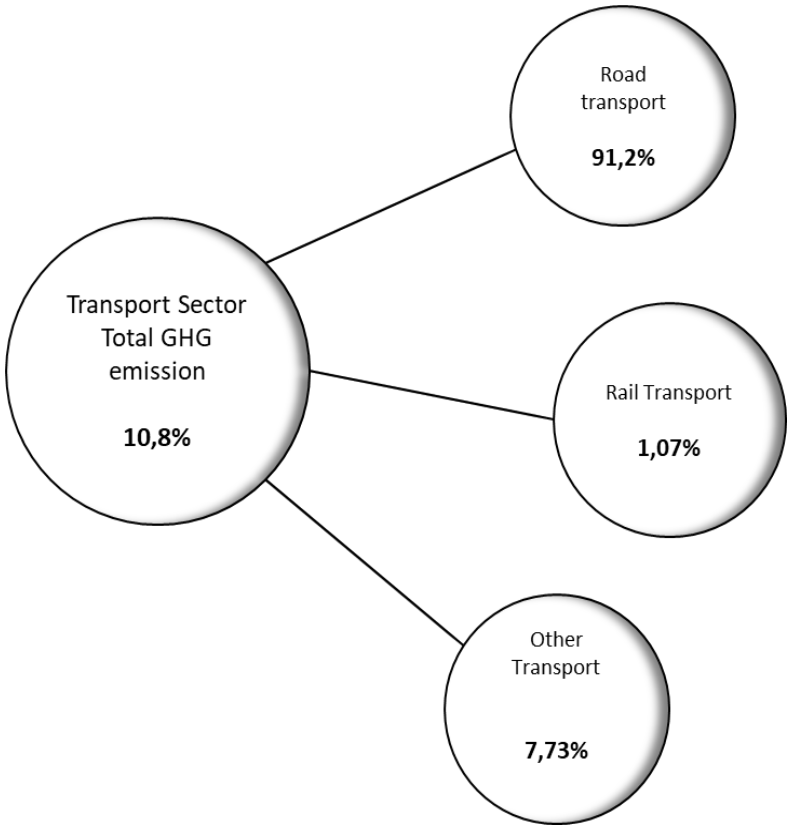


Figure 5.2: Emissions breakdown of the transport sector

Source: Author, 2020

Emission output is a global challenge; South Africa, in particular, is at risk to the severe effects of climate change as a water-scarce country. Drought and variability of rainfall because of climate change could have devastating consequences for this developing country. A hindrance to the country's move towards a low carbon economy is its heavy reliance on coal as the dominant energy source (DoT, 2018). The use of technology that promotes cleaner and efficient road freight transport needs to be developed in the freight industry together with regulatory action that facilitates a shift from road to rail to reduce the risk that the country is susceptible to, because of climate change.

Another cause for concern is road infrastructure. The high volume and weight that vehicles carry on the roads in South Africa accelerate the deterioration rates of the national roads. All roads are built with an expected lifecycle. Many of the roads in South Africa reach the end of their life cycle prematurely due to the traffic load and harsh weather conditions. Moreover, 30% of the infrastructure condition is rated poor or very poor while 78% of the national road network is thought to have surpassed its intended life design (DoT, 2018).

There are several risks and practices in South Africa's RFTS. Terblanche (2019) reports on intermediate outcomes because of risk components and non-compliance in heavy vehicle freight transporters in South Africa. Figure 5.3 groups the risk components, their intermediate outcomes, and their final impact as constructed by Terblanche (2019).

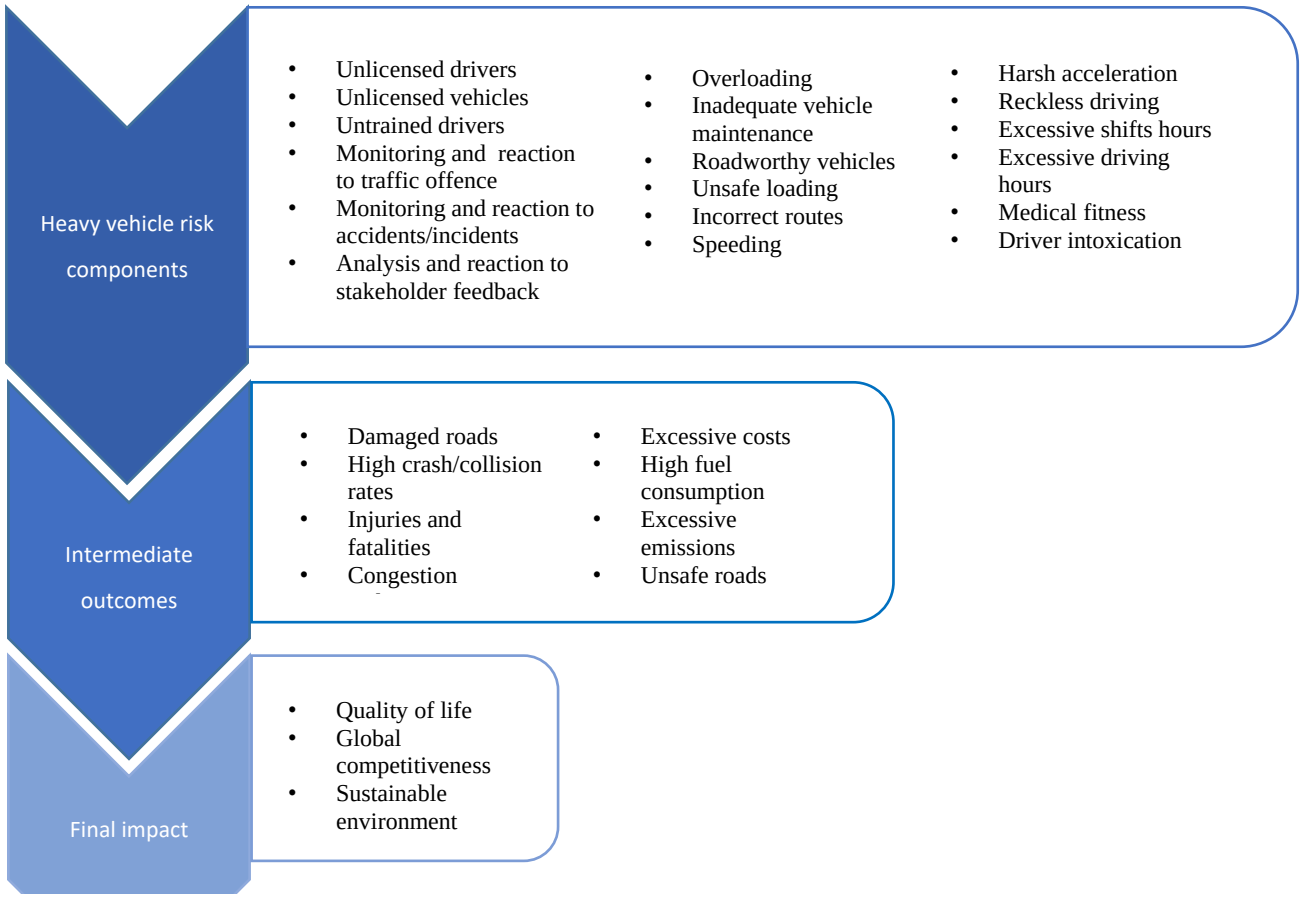


Figure 5.3: Heavy vehicle risk components

Source: Terblanche, 2019

5.2.2.1 Factors affecting the sustainability of RFTS

The University of Michigan, the Michigan University's Trucking Industry Program Advisory Board, and the Northwestern University participated in a survey and discussions that concentrated on critical factors around long-term freight trucking sustainability that informed Richardson's sustainable transport analysis framework. Fundamental to understanding the RFTS is to understand the driving factors of the system. Richardson's (2005) article illustrated factors that affect the sustainability of RFTS in Figure 5.4.

Several papers discuss how the need for transport is derived (Viedermann, 1995; Litmann, 2009). Most agree that transport is a means to an end, and does not have a purpose of its own (Toth-Szabo & Varhelyi, 2012). Thus, its function primarily supports various economic activities and mobility needs. Rather than building up capital, road freight transport produces capital expenses for society, companies, and individuals (Rand *et al*. 2004). Figure 5.4 shows that road freight transport comes into play from market forces. The same market forces that affect demand for transport services, government policy that determines the rules of play, and other factors in the system.

The RFTS in Figure 5.4 deals with factors affecting safety, road regulations, fuel consumption, land use, congestion, driver behaviour, and the environment. Commencing with safety, Richardson (2005) explains the vehicle, the human and the environment are the key factors influencing road safety. The vehicle needs to first and foremost be roadworthy, licensed, receive adequate maintenance, and not be overloaded as identified risk components associated with the vehicle in Figure 5.4. The human being the driver is affected by physical, social, and psychological factors that link to the driver's training, experience, knowledge, and interest; these factors play a significant role in human error and crash avoidance. The final key factor is the road environment, the infrastructure condition. These include the state and quality of the roads, road lighting in the form of road reflectors or street lighting for night drivers are important to aid with road safety. The government is a key stakeholder in financing the road environment and developing road policies that create safe roads.

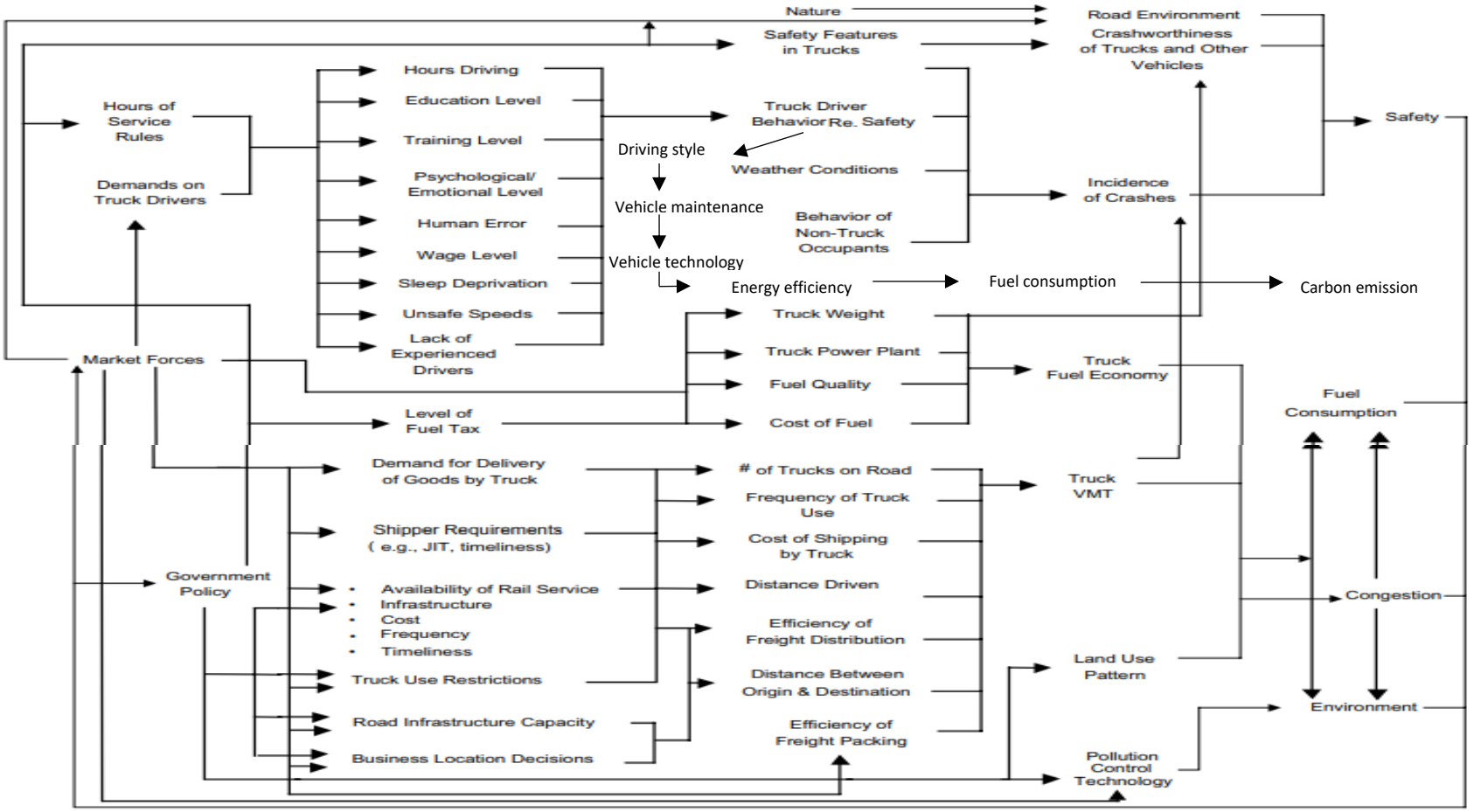


Figure 5.4: Freight factors affecting sustainability of the transport system

Source: Adapted from Richardson, 2005

5.1.4 M&E sustainability assessment framework for RFTS in South Africa.

The framework was developed for the freight transporter to assess their system's level of sustainability. The structure of the framework was based on Toth Szabo and Varhelyi's (2012) framework on indicators for measuring the sustainability of transport in the city. The sustainability themes and content within the framework were guided by the operational definition of the study, the aspirations of sustainable transport for the South African government. Furthermore, literature from the study's systematic literature review (SLR) and findings from the research questions were used. Figure 5.5 illustrates how the inputs were used in the development of the framework.

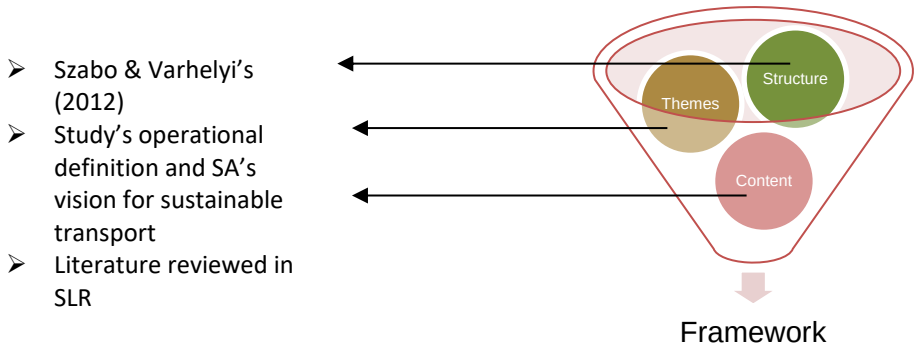


Figure 5.5: Inputs used in the framework

Source: Created by author, 2020

5.1.5 Framework structure

The first column of the framework (as included in Table 5.1) contains the Triple Bottom Line dimension (TBL) being focused on. All three dimensions of the TBL are addressed in the framework, namely: the social, economic, and ecological dimensions of sustainability. The second column of the framework contains the themes that were selected from the study's operational definition and themes related to South Africa's vision for sustainable transport. Next, the strategic objective or goal for each theme is followed by the inputs needed towards achieving the goal, the outputs of the framework, and a few possible measures.

The measures column in the framework are suggested measures with indicators found in articles reviewed in the SLR. These measures were selected for their relevance as measures for determining the input, outcome or goal within the theme it contained. The articles from the SLR were not able to furnish all the themes with measures and hence the measures provided in the framework are not a comprehensive list, but rather suggestions to provide possible measures for the sustainability themes.

Table 5.1: M&E framework for the sustainability assessment of RFTS

	Themes	Strategic Objective/ Goal	Input	Output	Measures
Social	*Safety*	Provide and maintain safe systems of work for the driver and vehicle through effective safety management practices. Decrease the number of annual fatalities and injuries recorded as relating to one's RFTS [1].	• Reasonable driving hours. • Monitoring and effecting consequences of traffic offenses [2]. • Driver training and periodic re-training. • RTMS certification [3]. • SQAS accreditation [4]. • Roadworthy vehicles. • Regular maintenance on vehicles. • Vehicle safety technology (e.g. remote speed sensing, collision damage mitigation braking system (CDMBS) and tracking devices). • PBS for the design and improved safety of vehicles [5]. • Night lights on vehicles [6]. • Safe loading and off-loading practices [7].	• Non-fatigued drivers. • Reduction in the number of road incidences [8]. • Improved driver behaviour [9]. • A road management system that promotes safety and efficiency. • A decrease in vehicle breakdowns. • Safer road environment.	• No. of crashes/accidents and injuries caused by one's RFTS annually. • No. of driver offenses [10] reported annually. • No. of road violations [11] registered annually. • No. of vehicle technology interventions. • No. of loading incidences [12].

	Stakeholders	Stakeholders are considered concerning to RFTS decisions that affect them directly. There is clarity of responsibilities among stakeholders.	• Consultation meetings with stakeholders (e.g. freight owner, agents, consumer, and government). • Collaborative tools where stakeholders can contribute their inputs.	• RFTS designed to incorporate stakeholders.	• No. of meetings held with stakeholders.
	Cost Considerations	Companies take responsibility for their full social cost [13] by mitigating the passing on of RFT [14] externalities costs [15] to society.	• Carbon Tax [16]. • Social and environmentally friendly RFTS initiatives. • Corporate social responsibility (CSR) [17].	• Companies and end consumers bearing the cost of air pollution, congestion and crashes caused due to operations.	• Amount of carbon tax paid. • No. of social or environmental initiatives. • Impact of CSR.

	Themes	Strategic Objective/ Goal	Input	Output	Measures
Economic	*Socio-economic*	Transport being a catalyst of socio-economic growth and development that benefits societies.	• Human and physical capital • Business growth/ expansion.	• Increased trade • Access to goods • Employment opportunities	• Market share growth • One's RFTS's contribution to GDP [18]. • No. of employees

	Cost Considerations	Generate profits from operations. Continuous productivity and growth.	• Financial, human and physical capital. • Strengthen customer relationships. • Offer competitive pricing.	• Income is greater than expenses. • Increase in productivity • Positive Return on Investment (ROI) [19]. • Expanded market share.	• Profit margin [20]. • Output per unit of input • ROI = Investment gain/ Investment cost • Increase in customer portfolio.
	Operational Efficiency	To generate income or outputs or returns equivalent or greater, for the same, or lower operating costs. Decrease the time and money lost due to congestion. Improved delivery process.	• Eco-driving [21]. • Loading facilities (loading and unloading equipment and space). • Efficient loading and unloading plan/schedule. • Route planning • Seek freight to transport for trips that usually return empty. Alternatively sign up to Apps [22] where one can bid to transport freight.	• Decreased fuel consumption. • Increased loading rate [23]. • Less GHG emissions • Reduced empty leg kms [24]. (Which in turn decreases costs and increases efficiency).	• Freight km travelled / Fuel expense. • The number of vehicles with efficiency technology. • The number of vehicles using cleaner energy. • No. people needed to off load or load a container or truck. • The time it takes to load or off load containers. • How many containers can be loaded or off loaded in a day. • Freight turnover rate (Tons x km) [25]. • No. of annual empty kms travelled.

	Modal Choice & Competitiveness	Offer modal choice that is competitive and boosts social-economic development.	• Fair and competitive pricing for the movement of freight. • Maintenance of physical assets. • Reinvestment into the business.	• Affordable freight transportation prices. • Physical assets that are in good condition. • Capacity to meet demand.	•

Themes	Strategic Objective/ Goal	Input	Output	Measures
Emissions	Decrease the business's RFTS emissions by 40-50% by 2050. The national target is a total of 5% for the transport sector.	• Pollution control technology • Cleaner fuels [26]. • Company goals and targets strategically aimed at contributing to reducing emissions in the RFT sector.	• A decrease in emissions • Cleaner emissions	• Annual fuel consumption (in litres) • No. of vehicles that use a cleaner or renewable fuels.
Resource consumption	Minimising waste and consumption of natural resources, promote their use in an ecological and sustainable manner.	• Recycle waste material [27]. • Reuse and refurbish materials.	• Using natural resources at rates equal to or less than the rate of replenishment.	• Annual recycled tons. • Annual reused or refurbished tons. • Freight tonnes /Energy used. • Km travelled /Energy used.
Preservation for the Future	Implement company policy that supports sustainability initiatives and protecting the environment for the benefit of present and future generations.	• Company policy and initiatives geared at sustainability.	• Conservation of resources.	• Cost % of sustainability initiatives the company has embarked on.

Numbers 1-25 are footnotes that correspond with the numbers contained in Table 5.1.

1. **RFTS:** Road freight transport systems;
2. **Effecting consequences to traffic offences:** driver tally, warnings, disciplinary action.
3. **RTMS certification:** The Road Transport Management System is an industry-led, government-supported, voluntary, self-regulation scheme that encourages consignees, consignors, and road transport operators to implement a management system (a set of standards) that demonstrates compliance with the Road Traffic Regulations and contributes to preserving road infrastructure, improving road safety and increasing productivity.
4. **SQAS:** accreditation for Safety Quality Assessment for Sustainability.
5. **PBS:** Performance Based Standards.
6. **Night lights on vehicle body:** small additional lights on the body of the truck to make the truck more visible at night or during bad weather conditions.
7. **Safe loading and off-loading practices:** For example, ensure the vehicle is stopped, braked, and stabilised, loading areas are well lit and free from hazard, always have trained personnel to use the loading and off-loading equipment.
8. **Road incidences:** loss of control of the vehicle causing an accident/crash or damage to goods, collisions with people or objects, includes fatalities, injuries or damage.
9. **Driver behaviour:** This refers to a driving style, how one breaks, accelerates, and behaves on the road.
10. **Driver offenses:** violations caused by the driver, i.e. speeding, ignoring signage, not wearing a seat belt, driving under the influence of alcohol, etc.
11. **Violations:** unlicensed vehicle.
12. **Loading incidences:** accidents, injuries, or fatalities caused by unsafe loading practices e.g. overloading.
13. **Social cost:** total cost to society; it includes private costs and external costs.
14. **RFT:** road freight transport.
15. **Externality costs:** activities that incur a cost or negatively affect other parties and is not financially incurred by the producer.
16. **Carbon tax:** a fee levied on fossil fuels with the intention to reduce emissions.
17. **Corporate social responsibility (CSR):** a business practice that integrates social accountability.
18. **GDP:** Gross domestic product.
19. **Return on Investment (ROI):** is a performance measure used to evaluate the efficiency of an investment. Calculated by taking the benefit or return of an investment divided by the cost of investment.
20. **Profit margin:** is the degree to which a company makes money. Calculated by dividing income by revenues.
21. **Eco-driving:** a driving style that minimises fuel consumption and emissions.
22. **Applications:** downloadable software applications.
23. **Loading rate:** speed or time it takes to move cargo in or out of a truck or container.
24. **Empty leg km:** the distance travelled with no cargo being transported.

25. **Freight turnover rate:** is the quantity of cargo multiplied by the distance transported.
26. **Cleaner fuels:** fuels that exert lesser greenhouse gas emissions (biodiesel, hydrogen, compressed natural gas (CNG)).
27. **Recycle waste material:** to reuse or repurpose waste materials, e.g. (tyres and parts).

The framework was developed to be used by road freight transporters. Each RFTS that utilises the framework must monitor the inputs for periodic evaluation. The framework was developed with the intention for annual assessments to be conducted by a designated personnel or team within the company/organisation that seeks to improve and assess the sustainability of their RFTS. The structure of the framework can be adapted and customised by each company/organisation to best suit their operations.

5.2 Expert Review

The framework developed to assist in the M&E of sustainability initiatives in RFTS's of road freight transporters in South Africa was reviewed by nine industry experts. Annexure 1 was prepared as a document that explains the development process of the framework, shows the framework, and the survey questionnaire for experts review of the framework. The annexure was sent out via email to 350 persons in the road freight transport industry.

Table 5.2: Background details of survey participants

Participant	Occupation	Background
1	Group SHEQ Manager	15 years SHEQ Management- Logistics industry
2	Transport and Logistics Consultant	More than 50 years in and around the road freight industry and related value chains
3	Manager at a transport company	MCom Logistics Management
4	Chief Innovation Officer	Engineer
5	CEO and CIO	CPA (North America), Fellow of ACCA, CAIB (SA), Former CFO of Supergroup Coal.
6	Principal Research Engineer	Mechanical Engineering
7	Financial Manager at a transport company	Finance
8	Researcher	Data modeller
9	Principal researcher: smart mobility	Operations research, information systems, industrial systems

The review for the survey is summarised as follows:

There were three questions linked to the ease of understanding the framework. Seven of the respondents found the framework shown in Table 5.1 easy to understand and work through with eight reviewing it as having a logical flow of the horizontal headings as shown in Figure 5.6.

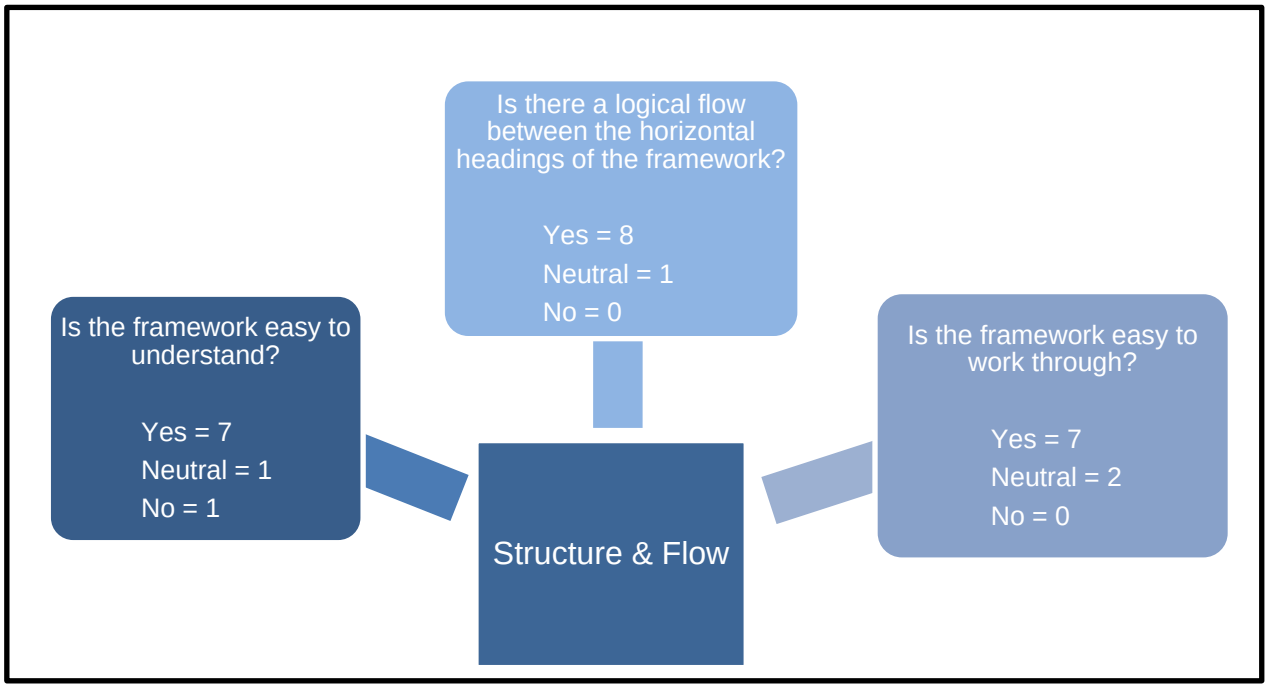


Figure 5.6: Summary response on structure and flow

Figure 5.7 is linked to the appropriateness of the themes, the framework as a guide for the sustainability of RFTS, and assisting towards adopting a more holistic sustainability approach. Three respondents were indifferent about the sustainability themes used as vertical headings in Table 5.1 contributing towards holistic sustainability, six of the nine thought they did. Eight out of nine experts viewed the framework as having the potential to assist towards holistic RFTS sustainability, whilst five of the nine agreed that the framework may guide sustainability in RFTS.

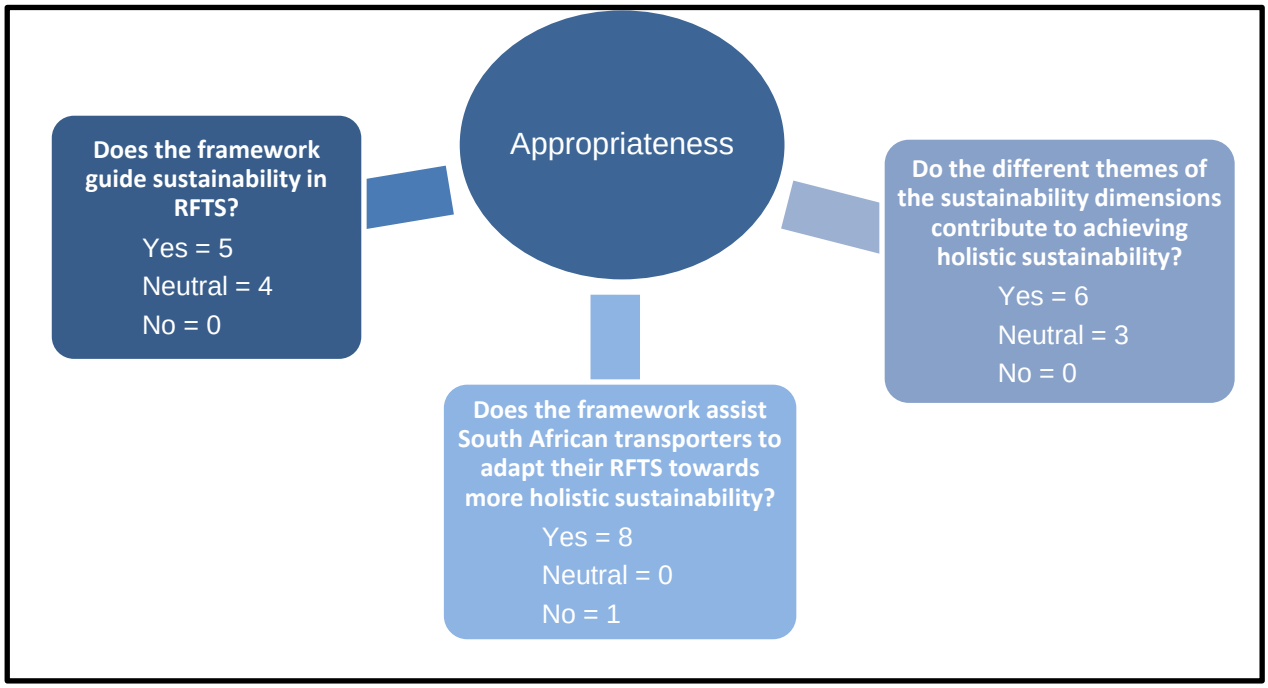
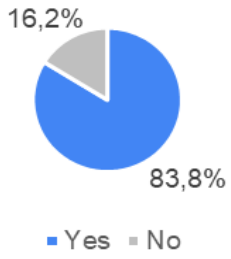
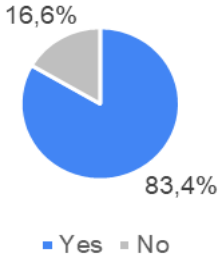


Figure 5.7: Summary response on the appropriateness

Regarding the inputs and goals, the respondents were requested to state whether each input is implementable by road freight transporters and if each goal is attainable. The results were as summarised in Table 5.3.

Table 5.3: Summary response on feasibility

Feasibility	
Are the inputs implementable by South African transporters?	Are the strategic goals realistic / attainable for the South African environment?
• The majority (83.8%) answered (YES): 	• The majority (83.8%) answered (YES): 

As shown in Figure 5.8, seven out of the nine respondents regarded the developed framework to be aligned to the study's operational definition of sustainability in the transport sector; which encompasses all the key themes and elements contained in the 16 definitions the study investigated. The framework's alignment to government's vision of transport sustainability had five of the nine in consensus that the framework aligns to the South African vision whilst four of the nine were indifferent.

Figure 5.8: Summary response on the South African government's vision and study's operation definition

Inputs to improve the framework were requested from the experts. Some inputs were given for more measures used in industry relevant to the framework. These suggestions included technological aspects such as the state of readiness and adoption, addressing fraudulent licensing of vehicles and drivers, as well as compliance of vehicle designs. Additional suggestions in Table 5.4 were added to the framework in Table 5.1.

Table 5.4: Inputs from the respondents

Incorporated Feedback	Under operational efficiency PBS - for design and improved safety was incorporated.
	Safety Quality Assessment for Sustainability (SQAS) accreditation as an input under the safety theme.
	Under the economic dimension to include a profitability theme for evaluation.
	Driver re-training.

Furthermore, the respondents were asked if they would need an incentive to implement a sustainability framework for RFTS. The majority of the respondents 5/9 said no. One respondent was not sure and the three that answered yes, mentioned their interest of incentives in the form of rebates, a decrease or subsidy on Sasria insurance, and relief on carbon tax for compliant companies.

The survey sought to obtain feedback from industry experts for the validity and reliability of the developed framework. Overall, the respondent's feedback was positive towards the framework; their feedback on additional inputs, themes, and measures were considered and where suitable incorporated into Table 5.1.

5.3 Conclusion

Litman (2003) stresses the importance of goal setting, which formed a key component in the framework's development. Theoretically, sustainability for transport systems is clearly defined and described by the study's operational definition and as appearing in documents of the South African DoT. Within the transport sector, road contributes the most towards negative externalities, and hence, is identified in the study as the mode that would in turn significantly contribute to addressing the unsustainable challenges in the sector. To develop an effective framework for sustainability assessment of RFTS in South Africa, the relationship of factors that affect the RFTS' sustainability were looked at as well as prominent road risks and challenges faced in the country.

Goals, inputs, outputs, and measures were put together for the sustainability assessment of RFTS in South Africa, to be used by road freight transporters. The framework was reviewed by industry experts who validated the framework and shared their inputs.

CHAPTER 6: CONCLUSIONS, RECOMMENDATIONS AND FUTURE WORK

6.1 Introduction

This chapter provides conclusions and recommendations for the study. The specific topics covered in the chapters form the main conclusions in section 6.2, recommendations to help improve sustainability initiatives. Possible research for future studies are presented in sections 6.3 and 6.4.

6.2 Conclusions

Freight transport systems play an integral role in society and their reach has been expanded by globalisation and networks that have given access to a wider range of goods to people through different transport modes. Although, the expansion of freight links has many benefits to the end users, the service freight transport offers simultaneously produces negative externalities as a result of its operations. These have adverse consequences on the social, economic, and environmental aspects of human livelihoods. As such, freight transport is a concern for many countries and organisations globally.

The increased demand, particularly of road freight, which is reported to contribute the most towards the negative externalities (congestion, noise, crashes, and GHG emissions) of transport systems, was catalysed by the deregulation of road transport. The shift of large volumes of freight from rail to road has led to congested roads, the premature aging of road infrastructure, poor road safety, and health hazards. The negative effects of the increased demand for road freight require multi-stakeholder collaboration in attempting to develop more sustainable road freight transport systems (RFTS).

As laid out in the South African government's Green Transport Strategy 2050, there is a will to develop road freight transport sustainably (DoT, 2018). Strategic plan documents and legislature in the country already exist that advocate for the right to a safe environment with measures to guard against ecological degradation and socio-economic development for the benefit of present and future generations. Goals reviewed by industry experts on RFTS sustainability in the study's developed framework were viewed as obtainable by the majority of the experts. However, we have not arrived at an ideal state of sustainability within RFTS and more effort is required from all road freight transport stakeholders to achieve this target. More must be done by the South African government regarding the implementation of their sustainability plans and support to the industry.

In closure, the study achieved its aim and met all its objectives. The sustainability construct was unpacked through the literature review on sustainability, and an operational definition of sustainability in the transport sector was put together determining the features of the variables (economic, social and environmental dimensions) within the transport sector. This aided the development of the study's M&E sustainability framework which has potential to guide holistic sustainability in RFTS in South Africa.

6.3 Findings

The main findings of the study stem from the research questions. These findings are from the literature reviews and the expert review of the developed framework.

6.3.1 RQ1: How is sustainability defined in the road freight transport sector?

It was found that the concept of sustainability dates to the 1600s and was developed to restore and preserve the natural environment and its ecosystems. From the initiation of the subject, its main focus was to address deforestation with links to environmental matters, which over the years evolved to include more disciplines such as economics and social aspects. Although the other dimensions are growing in exposure, the environmental dimension still receives a lot of attention. The same was found in the literature reviewed regarding sustainability frameworks for RFTS. Some of the frameworks did not address all three dimensions of sustainability; the majority of the reviewed frameworks regarding the sustainability of road freight transport, predominately dealt with topics that address environmental concerns.

Defining sustainability in the transport sector proved to be a complex and ongoing task due to lack of standardised definitions of transport sustainability. Despite this, reoccurring and common themes and terms were found in numerous definitions used globally. There is a general uniformity of the key ideas and elements that inform transport sustainability as defined by various authors.

6.3.2 RQ2: What M&E frameworks are available to measure the sustainability of road freight transport systems both globally and in South Africa?

The literature reviewed on M&E sustainability assessment frameworks reveals that there are different approaches to M&E frameworks. The popular focus is on performance or results-based approaches in the form of logical frameworks, which incorporate indicators to measure performance. There is also no standard framework to measure the sustainability of transport

systems, as the purpose of developing a framework and the focus of measurement differs amongst authors.

Although M&E sustainability assessment frameworks are tools widely used across many disciplines such as human development, health research, education, and environmental management, there were limited academic publications from the study's systematic literature review (SLR) on M&E frameworks that assess the sustainability of RFTS. This study gathered a total of 31 relevant peer-reviewed documents from four academic databases after removing -non-relevant, duplicated, and no full-text access articles. The search found limited articles that specifically addressed road freight transport system sustainability in South Africa.

The document results show that transport systems have been measured and evaluated by various models and frameworks. The frameworks found from the SLR can be classified to fall predominately in three categories, namely: those on decision-making methods, those that are indicator-based frameworks, and lastly, those that are conceptual frameworks.

6.3.3 RQ3: Do the available frameworks measure sustainability holistically?

The results obtained through the SLR for RQ3 indicate that some documents investigated sustainability holistically within the road freight transport sector, but did not necessarily provide a framework for assessment.

The reviewed documents from the SLRs assessed, developed, implemented, and analysed factors within the road transport sector relating to sustainability. Some articles presented a unique framework that had special applications for different contexts and with different outcomes. The articles reviewed addressed aspects of the Triple Bottom Line (TBL) in the sense that they spoke to environmental, social, and economic issues.

The SLR for the search for M&E sustainability frameworks for road freight in South Africa resulted in only one document that contained "South Africa" across four databases. The article was not relevant for this study, because it focused on rail freight transport in South Africa.

The results reviewed from RQ3's SLR search show that 87.5% of the documents reviewed did not address all the dimensions of the TBL; the majority of the reviewed documents tended to only address the environmental aspects of sustainability.

6.3.4 RQ4: How can an M&E framework be developed to measure a road freight transport system's sustainability in South Africa?

A framework was developed for RFTS in South Africa using inputs obtained from the literature reviews. The reviews revealed different approaches for developing a sustainability assessment framework for transport systems. For this study, the structure from Toth Szabo and Varhelyi's (2012) research was adapted. Themes emerging from content analysis in research question one were categorised into the three pillars of sustainability (social, economic and environmental dimensions). Goals in line with the theme and sustainability for the road freight transport sector were developed, inspired by the operational definition of the study, and the South African DoT vision for sustainable transport as well as their 2050 Green Transport Strategy. The outputs and measures were derived by the inputs which were driven from the goals.

6.3.5 RQ5: What international best practices are used in the road freight transport sector?

The best practice intervention types and actions for road freight transport reported by UNTACD fall under technology and innovation, fuel related measures, strategic and operational measures, regulatory and other soft measures. Concerning road infrastructure and connectivity, South Africa has one of the most advanced transport infrastructures on the African continent (World Economic Forum, 2019) and was ranked fifth by the WEF (2018) with regard to road connectivity globally. For the LPI rankings by the World Bank, the country was ranked at number 33 out of 160 countries. From these rankings, South Africa does not perform badly, but there are still best practices that the country and road freight operators can implement under the intervention types and actions.

6.4 Recommendations

There are short-, medium- and long-term recommendations for industry emanating from this study. Short term recommendations are achievable within one to two years and are not significantly demanding financially. The first short term recommendation would be improvements on system efficiency and optimization. This has benefits for the road freight transporter's operations. The broadness of the recommendation leaves room for flexibility, which allows each road freight transporter to adopt an initiative that can be feasibly implemented with the resources that they have. Route planning and freight consolidation are examples of attaining system efficiency and optimization. The second short term recommendation would be to ensure regular maintenance is

done on all their vehicles and equipment; and that the personnel operating the vehicles and equipment are trained as well as re-trained after a period of time. Such practices and initiatives do not only achieve a safe RFTS but optimise operations for the industry as a whole.

Medium term recommendations that could take between three to five years relate to technological and innovative initiatives. This category contains a range of solutions. However, financial requirements associated with this category deter its implementation. Technology features include artificial intelligence (AI) such as vehicle safety sensors or cameras to improve driving and prevent road crashes/accidents. Another example are fuel saver and emission reduction devices that automatically switch off a vehicle when idling and reduce fuel consumption through eco-driving features.

Long term recommendations require commitment towards the sustainability of the South African RFTS. This could be achieved through designing and nurturing a culture and practices in the industry that support sustainability across RFTS. For instance, PBS is an approach to heavy vehicle design and operations as researched with the potential to reduce road wear, safety exposure risk and improve performance and productivity. Other sustainability practices include targets on profitability and emissions, Corporate Social Responsibility (CSR), driving behaviour, vehicle speed limits and organisational behaviour/culture and are considerations to be incorporated in the sustainability policies that govern their systems.

Among the challenges in RFTS, factors related to safety and emissions are the most problematic. Emissions can also be combated with the move to cleaner fuels or renewable energy, which in most cases requires a change in fleet type/engines. Although this type of an initiative is ideal, it requires substantial investments.

The short, medium and long term recommended practices and initiatives contribute towards economic, social and environmental sustainability of RFTS. They have the potential to improve operational efficiency, save costs and create more sustainable RFTS.

6.5 Future work

This study recommends that more research be conducted on holistic sustainability giving focus to the social and economic dimensions within transport and logistics. Due to the limitations in the compilation of measures for RFTS in this study, future work can incorporate more measures for assessment by focusing on the measurement aspect of the framework. Furthermore, a scoring

dimension can be added to the framework where companies can quantify how compliant they are for benchmarking purposes.

Transport systems are unique and operated differently, thus, it would be fitting to develop frameworks that are more appropriate to the South African context. This is necessary so that road freight transporters operating in South Africa can have a variety of options of sustainability assessment frameworks that are appropriate for their specific transport system. The generic framework Table 5.1 can be further customised into separate frameworks for specific sub-categories of the road freight transport sector or customised by stakeholders to fit their own goals, inputs, outputs, and measures to assess the sustainability of their RFTS. Lastly, a similar framework should be developed for the South African government to track their progress in freight transport sustainability as they are also a key role player with regard to road freight sustainability in South Africa.

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Annexure

Validation Questionnaire

Thesis: Development of a Monitoring and Evaluation Framework for the sustainability assessment of Road Freight Transport Systems in South Africa

C. LALENDLE

Department of Logistics - Stellenbosch

Supervisor: Prof Goedhals-Gerber

Co-supervisor: Dr Van Eeden

CONTENTS

LIST OF TABLES

LIST OF FIGURES

PART 1

1.1 Introduction

This document was constructed for the validation process of the monitoring and evaluation framework the thesis sought to develop. The document contains information on the inputs used to develop the framework, the framework, and its intent, a glossary of terms used in the framework as well as the questionnaire used in the validation process.

1.2 Framework inputs

The framework was developed for the freight transporter to assess their system's level of sustainability. The structure of the framework was based on Toth Szabo and Varhelyi's (2012) framework on indicators for measuring the sustainability of transport in the city. The sustainability themes and content within the framework were guided by the operational definition of the study, the aspirations of sustainable transport for the South African government and literature reviewed from the study's systematic literature review (SLR). Figure A-1 shows how the inputs were used in the development of the framework.

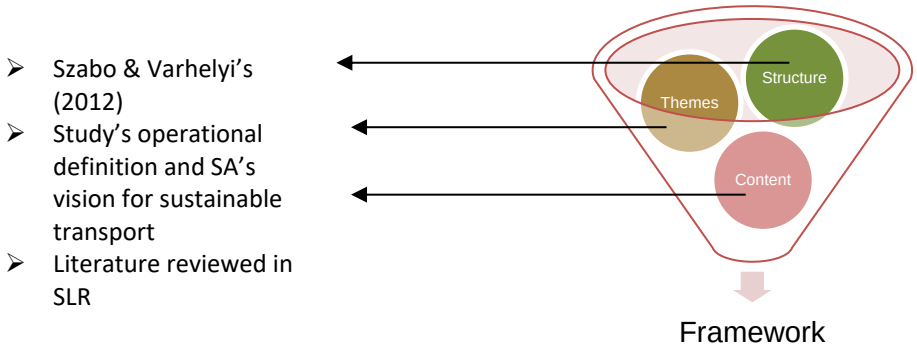

Figure A-1: Inputs used in the framework

1.3 Framework structure

The first column of the framework (as included in Table 1) contains the triple bottom line (TBL) dimension being focused on. All three dimensions of the TBL are addressed in the framework, namely; the social, economic, and ecological dimensions of sustainability. The second column of the framework contains the themes that were selected from the study's operational definition and themes related to South Africa's vision for sustainable transport. Next, the strategic objective or goal for each theme is followed by the inputs needed towards achieving the goal, the outputs of the framework, and a few possible measures.

The measures column in the framework are suggested measures as found in articles that had indicator-based frameworks in the study's SLR. These measures were selected as they were seen as relevant as a measure to determine the input, outcome, or goal within the theme it is found in. The articles from the SLR were not able to furnish all the themes with measures and hence the measures provided in the framework are not a comprehensive list, but rather suggestions to provide possible measures for the sustainability themes.

PART 2

2.1 The developed framework

The framework provided in Table 1 is intended for road freight transporters in South Africa to assess their transport system's sustainability. The framework can be used to guide the transporters towards systems that are economically viable, socially equitable, and environmentally conserving (holistic sustainability). This framework can be used annually by road freight transporters to monitor and evaluate their system's sustainability, by measuring their efforts in the form of inputs against the outputs they experience and suggested measures. A glossary defining acronyms, meanings of phrases, and examples is provided after the framework.

Table A-1: Monitoring and Evaluation Framework for sustainability assessment of road freight transport system

	Themes	Strategic Objective/ Goal	Input	Output	Measures
Social	*Safety*	Provide and maintain safe systems of work for the driver and vehicle through effective safety management practices. Decrease the number of annual fatalities and injuries recorded as relating to one's RFTS [1].	• Reasonable driving hours. • Monitoring and effecting consequences to traffic offences [2]. • RTMS certification [3]. • Roadworthy vehicles. • Regular maintenance on vehicles. • Vehicle safety technology (e.g. remote speed sensing, collision damage mitigation braking system (CDMBS) and tracking devices). • Night lights on vehicles [4]. • Safe loading and off-loading practices [5].	• Non-fatigued drivers. • Reduction in the number of road incidences [6]. • Improved driver behaviour [7]. • A road management system that promotes safety and efficiency. • A decrease in vehicle breakdowns. • Safer road environment.	• No. of crashes/accidents and injuries caused by one's RFTS annually. • No. of driver offences [8] reported annually. • No. of road violations [9] registered annually. • No. of vehicle technology interventions. • No. of loading incidences [10].
	Stakeholders	Stakeholders are considered with regards to RFTS decisions that affect them directly. There is clarity of responsibilities among stakeholders.	• Consultation meetings with stakeholders (e.g. freight owner, agents, consumer, and government). • Collaborative tools where stakeholders can contribute their inputs.	• RFTS designed to incorporate stakeholders.	• No. of meetings held with stakeholders.

	Cost Considerations	Companies take responsibility for their full social cost [11] by mitigating the passing on of RFT [12] externalities costs [13] to society.	• Carbon Tax [14]. • Social and environmentally friendly RFTS initiatives. • Corporate social responsibility (CSR) [15].	• Companies and end consumers bearing the cost of air pollution, congestion and crashes caused due to operations.	• Amount of carbon tax paid. • No. of social or environmental initiatives. • Impact of CSR.

	Themes	Strategic Objective/ Goal	Input	Output	Measures
Economic	***Socio-economic***	Transport being a catalyst of socio-economic growth and development that benefits societies.	• Human and physical capital • Business growth/ expansion.	• Increased trade • Access to goods • Employment opportunities	• Market share growth • One's RFTS's contribution to GDP [16]. • No. of employees
	Cost Considerations	Generate profits from operations. Continuous productivity and growth.	• Financial, human and physical capital. • Strengthen customer relationships. • Offer competitive pricing.	• Income greater than expenses. • Increase in productivity • Positive Return on Investment (ROI) [17]. • Expanded market share.	• Profit margin [18]. • Output per unit of input • ROI = Investment gain/ Investment cost • Increase in customer portfolio.

	Operational Efficiency	To generate income or outputs or returns equivalent or greater, for the same, or lower operating costs. Decrease the time and money lost due to congestion. Improved delivery process.	• Eco driving [19]. • Loading facilities (loading and unloading equipment and space). • Efficient loading and unloading plan/schedule. • Route planning • Seek freight to transport for trips that usually return empty. Alternatively sign up to Applications [20] where one can bid to transport freight.	• Decreased fuel consumption. • Increased loading rate [21]. • Less GHG emissions • Reduced empty leg kms [22]. (Which in turn decreases costs and increases efficiency).	• Freight km travelled / Fuel expense. • Number of vehicles with efficiency technology. • Number of vehicles using cleaner energy. • No. people needed to off load or load a container or truck. • Time it takes to load or off load containers. • How many containers can be loaded or off loaded in a day. • Freight turnover rate (Tons x km) [23]. • No. of annual empty kms travelled.
	Modal Choice & Competitiveness	Offer modal choice that is competitive and boosts social-economic development.	• Fair and competitive pricing for the movement of freight. • Maintenance of physical assets. • Reinvestment into the business.	• Affordable freight transportation prices. • Physical assets that are in good condition. • Capacity to meet demand.	•

	Themes	Strategic Objective/ Goal	Input	Output	Measures
Ecological	*Emissions*	Decrease the business's RFTS emissions by 40-50% by 2050. The national target is a total of 5% for the transport sector.	• Pollution control technology • Cleaner fuels [24]. • Company goals and targets strategically aimed at contributing to reducing emissions in the RFT sector.	• A decrease in emissions • Cleaner emissions	• Annual fuel consumption (in litres) • No. of vehicles that use cleaner or renewable fuels.
	Resource consumption	Minimising waste and consumption of natural resources, promote their use in an ecological and sustainable manner.	• Recycle waste material [25]. • Reuse and refurbish materials.	• Using natural resources at rates equal to or less than the rate of replenishment.	• Annual recycled tons. • Annual reused or refurbished tons. • Freight tonnes /Energy used. • Km travelled /Energy used.
	Preservation for the Future	Implement company policy that supports sustainability initiatives and protecting the environment for the benefit of present and future generations.	• Company policy and initiatives geared at sustainability.	• Conservation of resources.	• Cost % of sustainability initiatives the company has embarked on.

2.2 Glossary (with meanings and examples of terms in the framework)

The glossary serves as footnotes for the framework. The numbers correspond to the numbers provided in the framework.

1. **RFTS:** Road freight transport systems;
2. **Effecting consequences to traffic offences:** driver tally, warnings, disciplinary action.
3. **RTMS certification: The** Road Transport Management System, is an industry–led, government-supported, voluntary, self-regulation scheme that encourages consignees, consignors and road transport operators to implement a management system (a set of standards) that demonstrates compliance with the Road Traffic Regulations and contributes to preserving road infrastructure, improving road safety and increasing productivity.
4. **Night lights on vehicle body:** small additional lights on the body of the truck to make the truck more visible at night or during bad weather conditions.
5. **Safe loading and off-loading practices:** For example, ensure vehicle is stopped, braked and stabilised, loading areas are well lit and free from hazard, always have trained personnel use the loading and off-loading equipment.
6. **Road incidences:** loss of control of vehicle causing an accident/crash or damage to goods, collisions with people or objects, includes fatalities, injuries or damage.
7. **Driver behaviour:** Is the driving style, how one breaks, accelerates and behaves on the road.
8. **Driver offenses:** violations caused by the driver, i.e. speeding, ignoring signage, not wearing a seat belt, driving under the influence of alcohol, etc.
9. **Violations:** unlicensed vehicle.
10. **Loading incidences:** accidents, injuries or fatalities caused by unsafe loading practices e.g. overloading.
11. **Social cost:** total cost to society; it includes private costs and external costs.
12. **RFT:** road freight transport.
13. **Externality costs:** activities that incur a cost or negatively affect other parties and is not financially incurred by the producer.
14. **Carbon tax:** a fee levied on fossil fuels with the intention to reduce emissions.
15. **Corporate social responsibility (CSR):** a business practice that integrates social accountability.
16. **GDP:** Gross domestic product.
17. **Return on Investment (ROI):** is a performance measure used to evaluate the efficiency of an investment. Calculated by taking the benefit or return of an investment divided by the cost of investment.
18. **Profit margin:** is the degree to which a company makes money. Calculated by dividing income by revenues.
19. **Eco driving:** a driving style that minimises fuel consumption and emissions.
20. **Applications:** downloadable software applications.
21. **Loading rate:** speed or time it takes to move cargo in or out of a truck or container.
22. **Empty leg kms:** the distance travelled with no cargo being transported.
23. **Freight turnover rate:** is the quantity of cargo multiple by the distance transported.
24. **Cleaner fuels:** fuels that exert lesser greenhouse gas emissions (biodiesel, hydrogen, compressed natural gas (CNG)).
25. **Recycle waste material:** to reuse or repurpose waste materials, e.g. (tyres and parts).

PART 3

3.1 Validation questions

The following questions serve to validate the framework. If you have any suggestions or comments to improve the framework, please feel free to include them.

Please copy and paste the link onto your web browser to take the questionnaire online:
https://docs.google.com/forms/d/e/1FAIpQLScX2C-726PvcV1F9DyWWSUw2izhqs7fJVuloXVMUIuG0bj0Sg/viewform

Participant name: _____
Email address: _____
Occupation: _____
Background: _____

		Participant's Response									
1.) How important are the themes for each sustainability dimension? Rank the 10 themes by marking with an X the importance of each sustainability theme, (1) - Representing most important and (10) - least important.											
	Themes	1	2	3	4	5	6	7	8	9	10
Social dimension	**Safety**										
	Stakeholders										
	Social Cost Considerations										
	Social economic										
Economic dimension	**Cost Considerations**										
	Operational efficiency										

	Modal Choice & Competitiveness										
Ecological dimensions	**Emissions**										
	Resource Consumption										
	Preservation of the future										

This question relates to the design and usability of the framework.

	Participant's Response					
	Mark with an X the on the statement you most agree with					
Structure and Process	**Strongly agree**	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**	**Comments**
	2.) The framework is easy to understand?					
	3.) The framework is easy to work through?					
	4.) Is there a logical flow between the horizontal headings of the framework (strategic objectives, inputs, outputs and measures)?					
Appropriateness	**5.) The framework guides sustainability in RFTS?**					
	6.) The different themes of the sustainability dimensions contribute to achieving holistic sustainability?					

<table>
<tr><td colspan="3">7.) Are the inputs implementable by South African transporters?</td></tr>
<tr><td>Social dimension Inputs</td><td>Economic dimension Inputs</td><td>Ecological dimension Inputs</td></tr>
<tr><td>• Reasonable driving hours.
• Monitoring and effecting consequences to traffic offences [2].
• RTMS certification [3].
• Roadworthy vehicles.
• Regular maintenance on vehicles.
• Vehicle safety technology (e.g. remote speed sensing, collision damage mitigation braking system (CDMBS) and tracking devices).
• Night lights on vehicles [4].
• Safe loading and off-loading practices [5].
• Consultation meetings with stakeholders (e.g. freight owner, agents, consumer, and government).
• Collaborative tools where stakeholders can contribute their inputs.
• Carbon Tax [14].
• Social and environmentally friendly RFTS initiatives.
• Corporate social responsibility (CSR) [15].</td><td>• Human and physical capital.
• Business growth/ expansion.
• Financial, human and physical capital.
• Strengthen customer relationships.
• Offer competitive pricing.
• Eco driving [19].
• Loading facilities (loading and unloading equipment and space).
• Efficient loading and unloading plan/schedule.
• Route planning
• Seek freight to transport for trips that usually return empty. Alternatively sign up to Applications [20] where one can bid to transport freight.
• Fair and competitive pricing for the movement of freight.
• Maintenance of physical assets.
• Reinvestment into the business.</td><td>• Pollution control technology.
• Cleaner fuels [24].
• Company goals and targets strategically aimed at contributing to reducing emissions in the RFT sector.
• Recycle waste material [25].
• Reuse and refurbish materials.
• Company policy and initiatives geared at sustainability.</td></tr>
<tr><td colspan="2">Mark with an X your answer below.</td><td rowspan="3">Comment if answered NO:</td></tr>
<tr><td>YES</td><td>NO</td></tr>
<tr><td></td><td></td></tr>
</table>

8.) The framework aligns with the South African government's transport sustainability goals?					
*"Provide **safe, reliable, effective, efficient,** and **fully integrated transport operations** and **infrastructure,** which will best **meet the needs of freight and passenger customers** at **improving levels of service and cost** in a fashion which **supports government strategie**s for **economic** and **social development** whilst being **environmentally** and **economically sustainable**".* –DOT (2007;1996)					
Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**	**Comments**
9.) The framework aligns with this study's transport sustainability definition?					
*A sustainable transport system is one that is **accessible spatially** allowing **mobility needs** to be met **safely and affordably** with **social cost considerations** (private cost and cost of externalities). The system **operates efficiently with infrastructure** that is an **asset to communities**, offering **modal choice** that is **competitive** and **boosts socio-economic development**; ensuring **future generations are not compromised** to cater for the needs of current societies. Sustainable transport **limits the emission** of air pollution, noise pollution and GHG's. **It reduces the use of land**, **consumption of non-renewable** and renewable resources as well as material resources needed to support the transport system. It **minimises waste**, reuses and recycles its components. It decreases its impact on environments, **protecting ecosystems** and the global climate. Sustainable transport systems **support the economic, social and environmental pillars** and are designed to **involve stakeholders**.* (Definition developed by the author for the purpose of the study)					
Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**	**Comments**

<table>
<tr><td colspan="3">10.)Are the strategic goals realistic/ attainable for the South African environment?</td></tr>
<tr><td>Social dimension Goals</td><td>Economic dimension Goals</td><td>Ecological dimension Goals</td></tr>
<tr><td>• Provide and maintain safe systems of work for the driver and vehicle through effective safety management practices.
• Decrease the number of annual fatalities and injuries recorded as relating to your RFTS [1].
• Stakeholders are considered with regards to RFTS decisions that affect them directly.
• There is clarity of responsibilities among stakeholders.
• Companies take responsibility for their full social cost [11] by mitigating the passing on of RFT [12] externalities costs [13] to society.</td><td>• Transport being a catalyst of socio-economic growth and development that benefits societies.
• Generate profits from operations.
• Continuous productivity and growth.
• To generate income or outputs or returns equivalent or greater, for the same, or lower operating costs.
• Decrease the time and money lost due to congestion.
• Improved delivery process.
• Offer modal choice that is competitive and boosts social- economic development.</td><td>• Decrease the business’s RFTS emissions by 40-50% by 2050.
• The national target is a total of 5% for the transport sector.
• Minimising waste and consumption of natural resources, promote their use in an ecological and sustainable manner.
• Implement company policy that supports sustainability initiatives and protecting the environment for the benefit of present and future generations.</td></tr>
<tr><td colspan="2">Mark with an X your answer below.</td><td rowspan="3">Comment if answered NO:</td></tr>
<tr><td>YES</td><td>NO</td></tr>
<tr><td></td><td></td></tr>
</table>

<table>
<tr><td colspan="2"></td><td>11.)Does the framework assist South African transporters to adapt their RFTS towards more holistic sustainability?</td></tr>
<tr><td colspan="2">Mark with an X your answer below.</td><td rowspan="3">Comment if answered NO:</td></tr>
<tr><td>YES</td><td>NO</td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2"></td><td>12.)Are there measures you use or know of in industry, relevant to the framework, that are not currently added that you would like to see added in the framework?</td></tr>
<tr><td colspan="2">Mark with an X your answer below.</td><td>Comment with the measure if answered YES:</td></tr>
<tr><td>YES</td><td>NO</td><td></td></tr>
</table>

		13.)Do you have any inputs/suggestions for the improvement of the framework?
Mark with an X your answer below.		Comment if answered YES:
YES	**NO**	

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